



PDF hosted at the Radboud Repository of the Radboud University Nijmegen

The following full text is a publisher's version.

For additional information about this publication click this link.

<http://hdl.handle.net/2066/180503>

Please be advised that this information was generated on 2018-07-07 and may be subject to change.

Pragmatics of Enterprise Modelling Languages: A Framework for Understanding and Explaining

Marija Bjeković



Pragmatics of Enterprise Modelling Languages: A Framework for Understanding and Explaining

Marija Bjeković

Copyright: © 2017 Marija Bjeković

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing of the author.

Printed and published by Ridderprint BV, Ridderkerk, The Netherlands

Layout by Marija Bjeković

Cover design by Marija Bjeković and Ridderprint BV

ISBN 978-94-92380-93-7

EE-Network dissertation series: 2018-1



The research reported in this thesis was conducted at Luxembourg Institute of Science and Technology, under the auspices of the Institute for Computing and Information Sciences of Radboud University Nijmegen and the Enterprise Engineering Network. The research conducted has been partially sponsored by the *Fonds National de la Recherche Luxembourg*, via the PEARL programme.

Pragmatics of Enterprise Modelling Languages: A Framework for Understanding and Explaining

Proefschrift

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.H.J.M van Krieken,
volgens besluit van het college van decanen
in het openbaar te verdedigen op vrijdag 12 januari 2018
om 11:30 uur precies

door

Marija Bjeković

geboren op 2 november 1979
te Belgrado, Servië

Promotor:

Prof. dr. H.A. Proper

Copromotoren:

Dr. J-S. Sottet Luxembourg Institute of Science and Technology, Luxemburg

Dr. S.J.B.A. Hoppenbrouwers

Manuscriptcommissie:

Prof. dr. Th.P. van der Weide

Prof. dr. U. Frank

Universität Duisburg-Essen, Duitsland

Prof. dr. B. Thalheim

Christian-Albrechts-Universität zu Kiel, Duitsland

Paranimfen:

Nikola Obradović

Slavko Bjeković

Acknowledgement

After my master studies, and my work in software engineering industry in Serbia, the emerging interest in more research side of information systems engineering brought me to Public Research Centre Henri Tudor (now LIST) in Luxembourg in 2008. During my first years in the Centre, some opportunities to define a thesis subject surfaced on the projects I was involved in. However, this was not that convincing to me, and I especially did not like the idea of working on a subject almost totally on my own, with partially involved external supervisor, and no real connection with the groups and projects in the Centre. I was also not convinced I was going to make it in such conditions, along with all the restrictions a freshly started family implied. Still, I kept wondering under which conditions I may be willing to give it a try, until it is too late.

Later on, I started working on the project/programme on enterprise architecture and enterprise modelling led by Erik Proper. I enjoyed getting to know his freshly established group – sorry, team – and starting to work in the area which was already in my interest sphere. One day, totally unexpectedly, Erik enquired about my interest to do a PhD under his supervision (which, by the way, initially focussed on modelling language integration). It felt like everything was coming together for me: my imagined ideal conditions seemed to manifest right in front of my eyes: I would have the supervisor on site, I would work in a freshly formed team, the topic was interesting, and there seem to be no other way than to embrace this opportunity despite the perceived challenges, and my family life constraints. Without further reflection, I immediately accepted it.

I was blessed with supervisors who were great source of inspiration, support and encouragement. Erik, I am grateful for the freedom and support you have given me in shaping and exploring the chosen research subject. I value how carefully you attended to the choice of my co-supervisors, and how much you cared about setting up the right conditions for the PhD candidate to give its best. Not only this made me feel comfortable, but it made the entire process all the more enjoyable. And of course, If I had to chose just one word to best describe you and your involvement, for sure that one would be

the *enthusiasm*. Your enthusiasm for the academic research still impresses me. Anyone interested could try to brainstorm with you about some possible research directions around any topic. I am sure that not only would they be convinced, they would also be drowned by the waves of ideas coming out from you, pretty much as I was after several initial meetings. On a more serious note, your enthusiasm really gave some good wind to my sailing, and brought freshness and creativity whenever I felt a bit stuck. Outside of your formal role, I have greatly enjoyed our discussions and exchanges on our different cultures, languages, hobbies and all the rest.

Jean-Sébastien, thank you for being so sincerely involved in my work. I am amazed and grateful for the time and effort you invested to familiarise yourself with the disciplines I explored in the thesis. I look so much forward to learning from and working with you on the more applied terrain, which lies much more in your comfort zone, let's say. Finally, I will never forget how promptly you made yourself available whenever I was feeling down, and how much you cared that I regain motivation and see some light at the end of a tunnel in the bad moments. This meant so much to me, thank you for being a friend in need, thus a friend indeed. I hope this friendship continues for a lifetime.

Stijn, the words of encouragement I had from you during the first discussion we had in Nijmegen still resonate with me. I enjoyed our discussions on linguistics as much as I did our talks on meditation. Thank you for orienting me in exploring linguistic contributions and giving some valuable advice. Also, I enjoyed your Buddhist sutras on the margins of my chapters, that was really heart-warming. I guarantee to do more 'research' on it.

This thesis has been about language and language use, and certainly about my language use: my sentences, my expressions, and particularly my use of definite and indefinite articles. Hence I feel a special praise to my supervisors for language-specific edit is required. Jean-Sébastien, an immense gratitude goes to you for reading an $n+1$ version of my sections and chapters. I do not know how you managed to stay with me, and to help me restructure different parts and shorten my *philosophy style* sentences of many lines long. Erik, thanks for adding all the definite articles wherever I missed them, and then for removing some of the previously added articles as unnecessary in the subsequent versions of the same text. I felt a huge relief when I realised that I was not the only one whose definite/indefinite article device required some fine tuning. Luckily, we had a linguist who patiently came to the rescue after our edits, although at times annoyed by all the mess. So, Stijn, thank you for improving my written English.

During my work on the thesis, I was part of Erik's EE-team. This offered quite some Dutch characters, allowing me to learn so much about Dutch culture, in particular Dutch directness in communication, open-mindedness, attitude towards hierarchy, and sense of humour. Indeed, the EE-team somehow gathered together very unique characters from many cultures, and it was very interesting and enriching to be part of that team, and share so many social events together. As for me, our Sinterklaas event, with all the poetry and witty presents stand out from the rest. As for the members in its *iSee* incarnation of the EE-team, I would like to thank them for tolerating my working habits

during these years, in particular my creative mess and floor-friendly ‘desk’ in the corner of our common office.

I would also like to extend my gratitude to the members of HEEL project, who allowed me to use their work and materials in my research. Thank you for your trust and collaboration, and for your willingness to share so much in our discussions. I greatly enjoyed learning from you, and I hope my conclusions and observations can contribute to your future engagements.

The journey of these five years brought so many lessons on a more personal level. I had to learn how to stand with uncertainty, as well as make friends with and transform the energy of self-criticism into a more constructive one that was serving me, rather than hindering me. I now understand why Prof. Michel Léonard warned me that my perfectionism was a sign to him that maybe he should not offer me to work on the thesis. I also vividly remember how many times I was reminded by Jean-Sébastien of an important advice by Jean-Marie Favre: “*Une thèse ne s’arrête pas, elle s’interrompt*”¹. Any scientific contribution is somehow incomplete, flawed, and there is always space for maturation, refinement, more precision, etc. If one is perfectionist, these are even easier to find, but the challenge is to maintain a bigger perspective on it all. I consider that taming my overly critical mindset so that I can ‘complete’ this work is a big achievement, possibly more important than the thesis itself. While I greatly value critical thinking and the capacity to scientifically motivate and justify one’s choices and contributions, I find it equally important to accept the lack of perfection in one’s work, and to be content despite it. I feel this quality is not valued enough in academic circles nowadays, both with respect to one’s own work and the work of others.

Probably Life would have never brought me to this situation, had my parents not decided to support me in leaving Serbia and doing my Master studies in France. In our country’s situation in 2004, this decision was not so straightforward, and ensuring financial means to realise my project was far from trivial. Mom and dad, thank you for all your sacrifice, and also for your trust in my decisions. Finally, during the thesis period, your help in managing pressures of family life along with our heavy work schedule has been invaluable to both me and Nikola.

Lastly, thank you to my husband Nikola and my daughter Jana, you are my special ones. Nikola, you supported me when I suddenly decided to do the thesis, and stood by me all the way, despite the occasional price this had on our family life. I am happy and grateful that we found ways to be of support to each other during all the challenging times, not just this one. To Jana, you are a precious gift in our lives. You continue to teach us what true love, kindness and forgiveness really mean. Finally, I hope our family continues to nourish our growth as individuals and family members, and also our growth in terms of how we relate to the world in which we live.

¹One can never complete the thesis, it can only be interrupted.

List of Publications

Bjeković, M. Proper, H. A. and Sottet, J-S., Towards a coherent enterprise modelling landscape, In *Short Paper Proceedings of the 5th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modeling, Rostock, Germany, November 7-8, 2012*, CEUR Workshop Proceedings 933, CEUR-WS.org

Bjeković, M. Sottet, J-S., Favre, J-M., Proper, H. A., A Framework for Natural Enterprise Modelling, In *Proceedings of 15th Conference on Business Informatics, CBI 2013*, Vienna, Austria, July 15-18, 2013.

Bjeković, M. and Proper, H. A., Challenges Of Modelling Landscapes: Pragmatics Swept Under the Carpet?, In *Third International Symposium of BMSD*, 2013.

Bjeković, M. and Proper, H. A., Enterprise Modelling Languages - Just Enough Standardisation?, In *Business Modeling and Software Design - Third International Symposium, BMSD 2013, Revised Selected Papers*, Noordwijkerhout, The Netherlands, July 8-10, 2013.

Bjeković, M. Proper, H.A. and Sottet, J-S., Embracing Pragmatics, In *Proceedings of 33rd International Conference on Conceptual Modeling, ER 2014*, Atlanta, GA, USA, October 27-29, 2014.

Zarwin, Z. Bjeković, M. Favre, J-M. Sottet, J-S. and Proper, H.A. Natural Modelling, *Journal of Object Technology*, Volume 13, No. 3, 4: 1-36, 2014.

Contents

I	Overview	1
1	Introduction	3
1.1	Context: Enterprise Modelling	3
1.2	Motivation: Use of Engineered and Standard Modelling Languages	5
1.2.1	Challenges of Language Standardisation	6
1.2.2	Observations of Modelling Language Use	7
1.2.3	Perspectives on Modelling Language	7
1.3	Research Challenge	8
1.4	Research Objective and Research Questions	9
1.5	Contributions	11
1.6	Thesis Structure	12
2	Research Approach	15
2.1	Philosophical Stance	15
2.2	Theory and Scientific Explanation	17
2.3	Method Pluralism and Adopted Research Approach	18
2.3.1	Method Pluralism	18
2.3.2	Research Methods Used	21
2.4	Summary	25
3	Background and Terminology	27
3.1	Signs and Semiotics	27
3.1.1	Different Sign Notions	27
3.1.2	Symbols, Icons and Indices	29
3.1.3	Semiotic Study of Signs	29
3.2	Natural Language and Linguistics	30
3.2.1	Formalist Orientation in Linguistic Studies	30
3.2.2	Functionalist Orientation in Linguistic Studies	31
3.2.3	Cognitive Orientation in Linguistic Studies	32
3.3	Languages for Modelling	32

3.3.1	Elements of Modelling Language Definition	33
3.4	Summary	34

II Conceptual Framework 37

4 A Fundamental

View on Modelling	39
4.1	Grounding and Method 39
4.2	Related Work: Constructivist Model Notion 43
4.2.1	Ontological Basis: World as Construction 44
4.2.2	Epistemological Differences 44
4.2.3	Human Cognition and Modelling 46
4.2.4	The Nature of Models 49
4.2.5	The Notion and Role of Purpose 54
4.2.6	Judgement of Model-Being 55
4.3	Reflection 55
4.4	Model Definition 56
4.4.1	Conception, Artefact, Model 56
4.4.2	Domain 57
4.4.3	Observer and Model-Being Judgement 57
4.4.4	Purpose 57
4.4.5	Illustration 58
4.5	Modelling Process and Role of Purpose 59
4.5.1	Terminological Considerations 59
4.5.2	Conceptualisation Stream 60
4.5.3	Manifestation Stream 62
4.5.4	Evaluation Stream 63
4.6	Summary 64

5 Conceptual Knowledge, Language and Conceptualisation 67

5.1	Motivation and Reference Disciplines 67
5.1.1	Position of Cognitive Linguistics 69
5.2	Structuring of Conceptual Knowledge 70
5.2.1	Embodiment as Foundational Premise 70
5.2.2	Cognitive Structuring Principles 72
5.2.3	Basic Organising Unit of Conceptual Knowledge: Idealised Cognitive Models 73
5.2.4	Concepts and Conceptual Systems 75
5.3	Functioning of Conceptual Systems 78
5.3.1	Schematicity, Entrenchment and Cognitive Salience . . . 79
5.3.2	Elaboration of Conceptual Systems 81
5.3.3	Conceptual Systems and Conceptualisation 82
5.4	Summary and Discussion 85

6	A Fundamental View on the Role of Conceptual Modelling Languages	89
6.1	Method	89
6.2	Conceptual and Enterprise Models	90
6.3	Perspectives on Conceptual Modelling Language: Critique . . .	91
6.3.1	Traditional Normative Perspective	92
6.3.2	Communication Perspective	93
6.3.3	Summary and Motivation	94
6.4	Twofold Function of Conceptual Modelling Language: A Proposition	95
6.5	Linguistic Function	97
6.5.1	Understanding Linguistic Structure \mathbf{ML}_{LS}	99
6.5.2	Illustration of the Analytic Framework on BPMN	101
6.5.3	Positioning with Regards to Representational Analysis	105
6.5.4	Influence of Linguistic Structure \mathbf{ML}_{LS} on Conceptualisation	107
6.6	Representational Function	111
6.6.1	Recognisability of \mathbf{ML}_{RS} Symbols	112
6.6.2	Relationship between \mathbf{ML}_{RS} and \mathbf{ML}_{LS}	112
6.6.3	Utility of \mathbf{ML}_{RS}	113
6.7	Summary	113
III	Explanatory theory	115
7	Use of Enterprise Modelling Languages	117
7.1	Method	117
7.2	Field Study Design	120
7.2.1	Criteria for Field Study Selection	120
7.2.2	HEEL Project as a Field Study	121
7.2.3	Scope of Observation and Sampling Decisions	122
7.2.4	Research Process Overview	123
7.2.5	Data Collection	125
7.2.6	Data Analysis	126
7.3	Pragmatics of Enterprise Modelling Languages: Overview of Findings	129
7.3.1	Factors in Use of Enterprise Modelling Language	130
7.3.2	Intervening Factors	133
7.3.3	Language Adaptation	134
7.4	Linguistic Function: Detailed Findings and Discussion	135
7.4.1	Modelling Language Selection	135
7.4.2	Conceptualisation Stream: Levels of Reflection	138
7.4.3	Embodiment of \mathbf{ML}_{LS} in Conceptualisation	139
7.4.4	Pragmatic Coherence of \mathbf{ML}_{LS}	143
7.4.5	Method-like Guidance	145
7.4.6	Utility of \mathbf{ML}_{LS}	147

7.4.7	Language Adaptation	158
7.5	Reflection: Language Use, Adaptation and Abuse	163
7.6	Summary	168
8	Discussion	171
8.1	Validity Threats and Measures	171
8.1.1	Construct Validity	171
8.1.2	Conclusion Validity	173
8.1.3	Internal Validity	175
8.1.4	External Validity	176
8.2	Implications	178
8.2.1	Modelling Language as a Conceptual System: Underlying Pragmatics	178
8.2.2	Language Engineering	179
8.2.3	Learning Conceptual Modelling	181
IV	Closing	185
9	Conclusion	187
9.1	Overview of Thesis Contributions	187
9.2	Answering the Individual Research Questions	188
9.3	Critical Reflection on the Research Approach	190
9.3.1	Method Pluralism	190
9.3.2	Interpretive Approach	191
9.4	Proposals For Further Research	193
9.4.1	Linguistic Function and Language Use	193
9.4.2	Conceptual Modelling and Theories of Language Learning	194
9.4.3	Language Use in Collaborative Modelling	194
9.4.4	Model Monopoly as Factor of Modelling Language Selec- tion and Use	195
9.5	Closing Remarks	196
	Bibliography	199

List of Figures

1.1	The core contributions of the thesis and their relation to the formulated research questions	11
1.2	Thesis structure	12
2.1	Conceptual model to guide the configuration of research methods, taken from [Frank, 2006, p.43]	19
2.2	An overview of the adopted research approach	22
2.3	Configuration of the adopted research approach, structured and presented in accordance with the conceptual model underlying method pluralism proposal [Frank, 2006, p.43]	24
3.1	Sign as diadic notion, according to Saussure.	28
3.2	Peirce’s notion of sign as part of triadic relationship of signification, according to [Short, 2007].	28
4.1	A fundamental view on modelling: method aspects of the contribution.	40
4.2	A typical process log	58
4.3	Essential streams of the modelling process	61
4.4	Aligning of conceptions	62
5.1	Structuring principles of conceptual knowledge and language	71
5.2	Schematicity relations and cognitive salience.	79
6.1	A fundamental view on the role of conceptual modelling language: method aspects.	90
6.2	Conceptual/enterprise modelling effort: $\langle mc, O, p, ML \rangle$	97
6.3	A twofold function of conceptual modelling language	98
6.4	Conceptual perspective and conceptual organisation: key dimensions of ML _{LS}	99

6.5	The frequency of use of BPMN constructs and suggested grouping of concepts, taken from [Recker, 2010, p. 193]	102
6.6	Popular subsets of BPMN vocabulary, as reported in [zur Muehlen and Recker, 2008, p. 477]	104
6.7	Linguistic Function: continuous negotiation.	108
7.1	Explanatory theory, theoretical framework and justification context.	118
7.2	Streams of qualitative analysis, according to [Miles and Huberman, 1994, p.11]	119
7.3	An overview of the research process within interpretive field study	124
7.4	Time-oriented view on modelling progress in relation to the interviews held in the HEEL field study	127
7.5	Generic fishbone diagram used to visualise causes and hidden causes of some problem/effect.	129
7.6	High-level view on relationships between main variables	131
7.7	Factors Of Modelling Language Use	132
7.8	The factors of ArchiMate selection in the HEEL project	136
7.9	Overview of Linguistic Function factors.	138
7.10	Cost-Effectiveness of Linguistic Function: Factors	140
7.11	Excerpt from the internal document on modelling method in the HEEL project, last modification 17.12.2015	147
7.12	Method-like guidance and pragmatic coherence factors in the context of HEEL field study	149
7.13	The summary of utility of \mathbf{ML}_{LS} in the context of HEEL field study, using the analytic framework proposed in Section 6.5.1. .	150
7.14	The evaluation of \mathbf{ML}_{LS} utility in HEEL modelling effort, focus on conceptual perspective provided by ArchiMate (highlighted in red) part 1/2	152
7.15	The evaluation of \mathbf{ML}_{LS} utility in HEEL modelling effort, focus on conceptual perspective provided by ArchiMate (highlighted in red) part 2/2	153
7.16	The evaluation of \mathbf{ML}_{LS} utility in HEEL modelling effort, focus on conceptual organisation provided by ArchiMate, part 1/2. Elements pertaining to topical coverage are highlighted in blue colour, to granularity in green colour, and internal structure of ArchiMate in yellow.	156
7.17	The evaluation of \mathbf{ML}_{LS} utility in HEEL modelling effort, focus on conceptual organisation provided by ArchiMate, part 2/2. Elements pertaining to topical coverage are highlighted in blue colour, to granularity in green colour, and internal structure of ArchiMate in yellow.	157
7.18	Lab actor: Analysis Capability View	158

7.19	The overall organisation of the ArchiMate-based language variant in the HEEL project, reflecting the core concepts and structuring of the business reference model. Packages indicate the re-interpretation of layers as different perspectives on the same ecosystem.	159
7.20	The specific view on the ArchiMate-based language variant in the HEEL project, focussing on modelling of applications in the reference model.	160
7.21	Capability Modelling	161
7.22	The specific view on the ArchiMate-based language variant in the HEEL project, focussing on ecosystem perspective in the reference model.	162
7.23	Lab actor: Capabilities view	164
8.1	Co-construction of language and reality	180
1	Initial coding list, page 1/3	216
2	Initial coding list, page 2/3	217
3	Initial coding list, page 3/3	218
4	Business Challenges	225
5	Business Overview	226
6	Healthcare Actors view	227
7	Healthcare Services view	228
8	Information for Health view	229
9	Final coding list, page 1/6	236
10	Final coding list, page 2/6	237
11	Final coding list, page 3/6	238
12	Final coding list, page 4/6	239
13	Final coding list, page 5/6	240
14	Final coding list, page 6/6	241
15	Symbols used in visualising modelling process in Figures 16- 21: legend	242
16	Overview of challenges and decisions in modelling effort - part 1/6	243
17	Overview of challenges and decisions in modelling effort - part 2/6	244
18	Overview of challenges and decisions in modelling effort - part 3/6	245
19	Overview of challenges and decisions in modelling effort - part 4/6	246
20	Overview of challenges and decisions in modelling effort - part 5/6	247
21	Overview of challenges and decisions in modelling effort - part 6/6	248
22	Challenges per model version – overview based on the coded content	249
23	Modelling challenges – visualisation of the code classification .	250
24	Decisions per model version – overview based on the coded content	251
25	Decisions – visualisation of the code classification	252
26	Case dynamics view: Modelling challenges, decisions and consequences on the model and language use, overview	253
27	Case dynamics view: Modelling challenges, decisions and consequences on the model and language use, focussing on sector-level model . . .	254

28	Case dynamics view: Modelling challenges, decisions and consequences on the model and language use, focussing on actor-level model . . .	255
----	--	-----

List of Tables

4.1	Selected related work, scope and model definitions.	43
4.2	Selected related work, ontological and epistemological positions	45
4.3	Selected related work, features of models	51
7.1	Interview respondents	123

Part I

Overview

CHAPTER 1

Introduction

1.1 Context: Enterprise Modelling

Enterprise modelling(EM) aims at holistic modelling of various aspects of an enterprise, including its supporting information systems(IS). The discipline has its roots in information systems modelling. The very term *enterprise model*, used since the last decades of the twentieth century, is introduced from the need to develop IS aligned with business¹, asking for their joint consideration in the design [Frank, 2014b]. In this context, the term *enterprise* is not necessarily restricted by the boundaries of a single (private or public) organisation, but may also cover only relevant parts of an organisation, or go beyond its boundaries, e.g. referring to a cross-organisational collaborations.

Initially driven by the needs of interoperability in manufacturing systems (e.g. [Chen et al., 2008, Vernadat, 2002]), enterprise modelling was first understood as the art of externalising the knowledge of an enterprise, for the goals of understanding, engineering, optimising, evaluating and controlling business operations [Vernadat, 2002]. In this context, the focus of EM developments (e.g. [Bernus and Nemes, 1996, Kosanke and Vernadat, 1992]) was on conceptual and methodical frameworks for identifying, structuring and formalising “*the things of the enterprise*” [Vernadat, 2002, p.4309]. However, with recent developments in the field, EM is increasingly understood as an *instrument* intended to facilitate change in enterprises, not just in terms of visible business and technology assets, but particularly in terms of enhanced communication and collaboration between majors stakeholders [Barjis, 2009, Bubenko et al., 2010, Frank, 2014b]. These developments demonstrate an increasing awareness that effective EM

¹The distinction between *Business* and *IT*, due to their isolated consideration within their own disciplines, can be considered as obsolete, if we consider IT/IS as an integral part of business, and appreciate the fact that there are much more perspectives to take into account within enterprise modelling.

approaches need to also take into consideration non-tangible, social, aspects inherent to an enterprise as a complex socio-technical system [Barjis, 2009, Bubenko et al., 2010, Frank, 2002]. For instance, [Stirna and Persson, 2012b] define an enterprise model as an integrated *and* negotiated model of an enterprise, thus giving equal importance to an adequate design of the enterprise and to the shared understanding and consensus among stakeholders. Similarly, Barjis [2009] underlines that the acceptance and application of created enterprise models rests on active stakeholder participation in an EM process.

It is well-known that an enterprise has to be modelled from multiple perspectives [Frank, 2002]. This is, on one side, due to the complexity of an enterprise as a socio-technical system, but also on the other side, related to need to involve various stakeholders of different professional backgrounds and concerns within an EM process. The coordination of these, inevitably partial, perspectives on an enterprise into a coherent view lies at the core of any EM approach, and intends to ensure a more effective (re)design of an enterprise, as well as more effective decision-making.

Achieving the coordination across different modelling perspectives in EM is even more important as, typically, partial enterprise models are expressed in different modelling languages. This challenge is of course not new, and has for long been a topic in software engineering and IS engineering, e.g. [Finkelstein et al., 1992]. In a traditional approach to viewpoint management, the coordination of different perspectives is subsumed to the challenge of integrating parts into a whole: much like the use of views in databases, the partial modelling perspectives are all considered as reductive view of a given pre-structured whole. In that context, an integrated modelling language, which defines and relates isolated modelling perspectives, is intended to ensure the consistency of an overall model. This logic has been also been followed in different modelling languages and approaches targeting integrated EM, e.g. [Jacob et al., 2012, OMG, 2011, Stirna and Persson, 2012a, Vernadat, 2002].

Among these, the most ambitious attempt was the Unified Enterprise Modelling Language (UEML) [Vernadat, 2002], which aimed to predefine and integrate relevant EM perspectives within a minimal, complete and formally grounded conceptual foundation². Besides the integration of modelling perspectives, UEML also targeted to eradicate problems related to the proliferation of partially overlapping conceptual/enterprise modelling languages, which has been traditionally criticised as undesirable, poorly justified, and preventing model exchange, adoption of modelling techniques and maturation of modelling approaches [Oei et al., 1992, Vernadat, 2002, Wand and Weber, 1995]³.

²The idea of all-encompassing unified EM language was abandoned in UEML 2.0 [Harzallah et al., 2012], however the approach still remains tied to the idea of formal ontological modelling foundations, and requires the mappings of each EM language to the formal evolving enterprise modelling ontology.

³For instance, this situation has been criticised to be alike to a ‘Tower of Babel’ situation [Vernadat, 2002], whereby:

- “there are too many EM languages to learn and understand, as well as too many EM tools with completely different interfaces,
- there is instability of vocabulary and of modelling paradigms [...],

Nonetheless, the adequacy of purely engineering approaches to the problems of EM has already been questioned [Frank, 2014b]. Not only that the enterprise as socio-technical phenomenon cannot be considered as a priori given and well-defined whole, but it is, in each particular organisational context, subject to negotiation and consensus. At the same time, due to increasing range of application of EM, there is also an increasing variety of topics and stakeholders to consider, thus an increasing variety in modelling perspectives to cater for. Finally, [Frank, 2014b] also points that local “symbolic context” [Frank, 2014b, p. 945] of a particular enterprise shapes stakeholders cognitive perspectives, use of language, and is pivotal for facilitating common action and change.

According to [Frank, 2014b], this reveals a fundamental tension between assumptions of engineering approaches to EM and the nature of enterprises, whose variety of organisational configurations and socio-cultural contexts defies any standardisation of EM perspectives and modelling concepts [Frank, 2014b]. Consequently, Frank [2014b] claims that a more sophisticated support for EM should go beyond the limitations of formalisation and pure engineering approaches, and allow for adaptability of EM methods and tools to the specificities of different EM contexts.

1.2 Motivation: Use of Engineered and Standard Modelling Languages

The standardisation of conceptual/enterprise modelling languages is often used as a platform to ensure the unification and integration of modelling perspectives and constructs for a problem area, e.g. UML [OMG, 2003] for software design, BPMN [OMG, 2011] for process modelling, and ArchiMate [Iacob et al., 2012] for enterprise architecture, UEML [Vernadat, 2002] for enterprise interoperability.

While driven by legitimate ambitions, there is increasing empirical evidence [Anaby-Tavor et al., 2010, Bubenko et al., 2010, Kort and Gordjin, 2008, Malavolta et al., 2013, Recker, 2010, Sandkuhl and Lillehagen, 2008, zur Muehlen and Recker, 2008] that standardising and integrating effect of such modelling languages starts to erode in their actual use, mainly due to the need to accommodate specific modelling contexts. This is often manifested by the emergence of ‘local’ *dialect-like variants of original engineered and/or standard modelling language*. From the point of view of purely engineering considerations, this phenomenon has been typically considered as undesirable, and due to undisciplined use of standards. Nevertheless, this phenomenon has been recurring ever since the proliferation of first conceptual modelling languages [Chen, 1981], and is widely present in many contemporary conceptual and enterprise modelling languages, e.g. goal-oriented [Yu, 1997], value-oriented [Kort and Gordjin, 2008], process-oriented modelling languages [Ayala et al., 2005, Braun

-
- *there are many incompatible EM tools on the marketplace, which are not able to inter-operate and which can hardly exchange models,*
 - *there are no, or poor, formal foundations both for EM and EE” [Vernadat, 2002, pg. 4315].*
-

and Esswein, 2014, Malavolta et al., 2013], etc.

We believe that the existence of this phenomenon provides an indication of a more fundamental problem, namely the need to more deeply reflect on the relationship between modelling standards and practical needs for language support. In this context, the use of modelling languages in general, and more specifically, the factors underlying the emergence of dialect-like language variants need to first be better understood. However, this problem has not so far been subject of a thorough research.

1.2.1 Challenges of Language Standardisation

The potential benefits of an *engineered modelling language* are well-known. It provides a foundation for the development of tools and (semi-)automated model manipulations, e.g. analysis, simulation, model transformation, code generation, which holds promise of increasing the productivity and efficiency of modelling. The reuse of these potential benefits across the variety of uses in an application area is one of the central drivers of *modelling language standardisation*. Consequently, a standardised language stipulates a *standardised representation format*, at least at an abstract syntax and/or concrete syntax level, aimed for different uses of models within one or more problem areas.

Additionally, standard language often seeks to establish common ground for communication across various stakeholders and uses of models within a problem area. This is done through a standard vocabulary, which is to be used in modelling of an area, for various uses and stakeholders of models. For instance, the BPMN specification [OMG, 2011] states the ambition to provide the *common language and visual notation* for business and technical users of process modelling. Such an ambition is tied to the assumption that standard language enables to avoid frequent conceptual meta-discussions between stakeholders, and allows for efficient communication and knowledge transfer [Hoppenbrouwers, 2003].

However, according to [Egyedi, 2007], language standardisation runs the risk of resulting in comprehensive and/or generic standards, which are consequently, either difficult or too expensive to use. The fundamental tension between context-independence and accommodation of context-specificity is indeed inherent to any standard definition process [Egyedi, 2007, Frank, 1998]. While reconciling these conflicting requirements involves degree of arbitrariness [Frank, 1998], the trade-offs made in language standardisation seem to frequently overemphasise the challenges of mechanical manipulation of models, and at same time disregard the variety of contexts, users and purposes for which the models need to be created.

In addition, language design decisions tend to also be biased by the knowledge, experiences and preferences of language designers [Frank, 1998]. While this bias may be inevitable, it is in particular pronounced in language standardisation context, due to its predominant techno-economical concerns. Consequently, this potential imbalance contributes to the risk of deteriorating basic language functionality.

1.2.2 Observations of Modelling Language Use

Although still scarce, empirical studies of the use of conceptual and enterprise modelling languages provide an additional indication that the trade-offs made in language engineering and standardisation may not be in tune with practical needs. For instance, [Anaby-Tavor et al., 2010, Bubenko et al., 2010, Kort and Gordjin, 2008, Malavolta et al., 2013, Sandkuhl and Lillehagen, 2008, zur Muehlen and Recker, 2008] suggest that, in the actual use, dialect-like variants of the original language emerge to compensate for the inability of these languages to aptly fit specific modelling contexts. Practitioners often cite the need to cater for organisation-specific aspects [Kort and Gordjin, 2008, Malavolta et al., 2013], for specific areas not already covered by the standard [Recker, 2010], as well for the audience and usage of the models, e.g. stakeholder-oriented communication or explorative modelling tasks [Anaby-Tavor et al., 2010, Bubenko et al., 2010, Malavolta et al., 2013]. In an extreme case, studies like e.g. [Anaby-Tavor et al., 2010, Malavolta et al., 2013] show that the practitioners even drop the use of standard/engineered modelling language and favour ad-hoc and/or home-grown semi-structured notations [Anaby-Tavor et al., 2010, Malavolta et al., 2013], despite the loss of potential benefits of language/tools. Although this behaviour may be frequently attributed to the lack of language training, or even abuse of modelling languages, [Anaby-Tavor et al., 2010, Davies et al., 2006, Kaidalova et al., 2012, Malavolta et al., 2013] indicate that actually modelling experts are particularly likely to opt for language adaptation, in an attempt to include (more) adequate modelling constructs, or bypass excessive rigidity and/or complexity of the language.

The extent of this phenomenon can best be illustrated using the available data of the use of BPMN standard, discussed in [Recker, 2010, zur Muehlen and Recker, 2008]. While BPMN as a standard aims to accommodate both business and technical purposes of process modelling, the analysis reveals a language which contains a great deal of excessive and rarely used constructs geared towards advanced technical purposes of process modelling, at the same time missing adequate constructs for business-level concerns [Recker, 2010, Wohed et al., 2006]. In practice, BPMN is indeed often adapted, through extensions or different ad-hoc adaptations, to allow for modelling of processes together with business rules, risks, organisational structure, performance indicators etc.

However, besides mostly empirical accounts of modelling practice, the *use of modelling languages* in general has not received much theoretical attention [Frank, 1998]. The research interest in this topic is only of recent date, but is mainly discussed in empirical reports, and rarely addressed from a theoretical perspective, e.g. [Agerfalk and Eriksson, 2002, Eriksson et al., 2013, Hoppenbrouwers, 2003, Hoppenbrouwers et al., 2005c]. Consequently, the factors underlying modelling language use and adaptation are still not sufficiently understood.

1.2.3 Perspectives on Modelling Language

The lack of interest in modelling language use also has a historical background. Modelling language studies have been originally influenced by formal studies of

language in analytic philosophy and linguistics. Drawing on this background, and with a preoccupation on mechanical manipulation of models, a modelling language has traditionally been conceived of as a system of symbols of a *normative character*. The focus of modelling language research has consequently been mainly oriented on the isolated consideration of syntactic-semantic qualities of language definition [Harel and Rumpe, 2004]. However, while a *normative* (and *formal*) specification of the modelling language is a prerequisite for obtaining predictable results from its mechanical manipulations [Bézivin, 2005, Karagiannis and Höfferer, 2006], the assumption that these properties hold in the human use of modelling languages across different modelling situations has to be questioned.

From a normative point of view, the need to control and limit the language to use in modelling is implicitly assumed and taken for granted. This is even more the case in language standardisation, where a standard language is expected to, on its own, increase the clarity of communication, facilitate knowledge transfer, and act as common language across various modelling situations and audiences. From this point of view, the use of modelling language is considered simply subject to a good training, and rather uninteresting from the research point of view. This comes as no surprise, given that formal approaches to natural language consider the area of language use – i.e. pragmatics – as a source of ambiguity, subjectivity and problems [Allwood, 1981, Cruse, 2011]. What is, however, unnoticed here, is that the phenomena of language and knowledge are never static, but inherently related to specific contexts and perspectives taken on the considered world/problem.

More recently developing branches in linguistics, precisely the family of functional approaches to language, e.g. [Clark, 1993, Geeraerts, 2010], place more emphasis on the roles that language plays in human life, and study the structure and content of language in relation to its function. In this context, pragmatics is seen as an integral part of the study of language, as within the use, the language finds its purpose. Inspired by these theories of language, few research works argued for broadening the scope of modelling language research, and for including pragmatics in the scope of modelling language studies, e.g. [Agerfalk and Eriksson, 2002, Eriksson et al., 2013, Hoppenbrouwers et al., 2005a, Proper et al., 2005, Thalheim, 2012]. In conceptual modelling, [Thalheim, 2012] introduces *modelling pragmatics* as the study of “*how languages are used for intended deployment functions in dependence on the purposes and goals within a community of practice.*” [Thalheim, 2012, p.8]. We believe that these pragmatics elements need to be taken into account in the study of modelling languages, in particular their use.

1.3 Research Challenge

Despite ambitions of language engineering and standardisation to further mechanical manipulations of models, the problems in the use of modelling languages appear much earlier, in the very process of modelling, more particularly within conceptualisation. Besides allowing effective mechanical manipulation of models, a modelling language also is intended to add value by providing a

specific ontological position to adopt in structuring conceptualisations [Falkenberg et al., 1998]. There is a wide-spread assumption in language engineering research that the conceptual foundation of a modelling language acts as a ‘filter’ [Falkenberg et al., 1998] on a domain of interest. However, the nature of this ‘filter’ and its functioning in relation to human conceptualisation and to conceptual knowledge are not well understood. The current assumptions of language engineering and standardisation indeed neglect this functioning, and overemphasise the challenges of mechanical manipulation, and hence a normative perspective on modelling languages. Although necessary for purely technical purposes of models, this orientation is not tenable when studying the use of modelling language within a socio-pragmatic modelling context, as it denies the principles of socio-cognitive functioning of languages [Clark, 1993, Cruse, 2011, Geeraerts, 2010, Wyssusek et al., 2002], as well as of the inter-subjective nature of conceptual knowledge [von Braun et al., 1999, Wyssusek et al., 2001a].

In this thesis, and in line with the functional approaches to natural language, we take the position that value of modelling language is inherently related to its use [Proper et al., 2005], and argue that drivers and factors underlying *use of modelling languages* need to be better understood from a theoretical perspective [Bjeković et al., 2014a]. To do so, we argue that it is necessary to go beyond a purely normative orientation often adopted in modelling language studies, as in our view, a broader perspective has the potential to contribute to a better understanding of drivers and factors underlying modelling language use, and (eventually) provide better explanation of the phenomena involved in modelling language ‘dialectisation’. This sets the *challenge of our research*.

While more flexibility and adaptability in language engineering for EM is argued for [Frank, 2014b], the decisions regarding modelling language scope, as well as identifying language aspects potentially subject to adaptation/variation are not trivial⁴. We believe that a deeper theoretical consideration of pragmatic factors of modelling, therefore also the use of modelling languages, may lay the foundation for better informed choices and trade-offs inherent in any language engineering approach.

1.4 Research Objective and Research Questions

The primary knowledge contribution, i.e, the **primary research objective** of the thesis is an *explanatory theory* of *how* and *why* enterprise modelling languages are used. Therefore, the **main research question** is formulated as follows:

What are the factors that affect the use of enterprise modelling languages?

The primary subject of study is the use of conceptual/enterprise modelling languages. As previously mentioned, we argue that to study the use, we first

⁴This challenge is, as discussed in [Frank, 2011a], not limited to generic languages such as UML and BPMN, but is also at stake in the design of domain-specific languages.

need to broaden the perspective adopted on the role of conceptual modelling languages. We study the role of modelling languages within the process of conceptual/enterprise modelling, and in relation to model purpose, modelling context, and related conceptual knowledge created and expressed through models. However, while the importance of purpose in modelling is widely acknowledged, this notion and its influence in modelling are rarely discussed in detail. Consequently, the main overarching research question is answered by addressing the following sub-questions:

***RQ 1.** What is the role of purpose in modelling, and specifically, how does it affect the process of model creation?*

***RQ 2.** What is the role of a modelling language in conceptual and enterprise modelling?*

***RQ 3.** What are the factors that affect the use of enterprise modelling languages?*

***RQ 4.** How can these factors explain the emergence of dialect-like variants of enterprise modelling languages in the actual contexts of their use?*

The main objective of **RQ 1** and **RQ 2** is to lay theoretical and conceptual foundations based on which the subject of modelling language use can be better understood. More specifically, **RQ 1** aims to clarify and define elements of modelling pragmatics [Thalheim, 2012] that are crucial to the study of how modelling languages are used, and in particular the role and influence of model purpose. Next to that, the main objective of **RQ 2** is to revisit the understanding of role that modelling languages play in the context of conceptual and enterprise modelling.

Based on the above-mentioned developments, we expect to identify factors that affect the use of enterprise modelling language, i.e. to answer **RQ 3**. By answering this question, we expect to also be able to better understand and contribute to the explanation of the phenomena of dialect-like variation of the enterprise modelling languages in the actual context of their use, i.e. to answer **RQ 3**. As previously discussed, the emergence of dialect-like emergence of an enterprise modelling language is in our thesis considered as part of the broader phenomena involved in modelling language use.

The **application domain** of our theory is restricted to enterprise modelling. Although some elements of the theoretical framework are general, we empirically study the functioning of modelling languages only within an enterprise modelling context, given the pivotal role that language has in this context. Consequently, at this stage of theoretical validation, we restrict the application domain of our theory to *enterprise modelling*.

1.5 Contributions

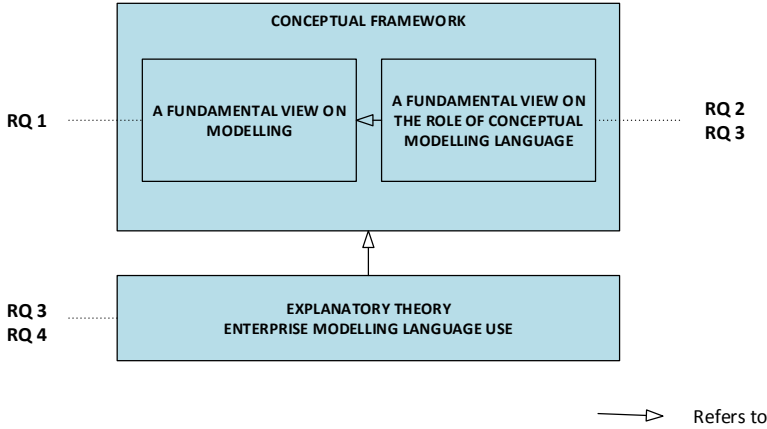


Figure 1.1: The core contributions of the thesis and their relation to the formulated research questions

The major contributions of this thesis comprise:

- **A fundamental view on modelling**, which is a result of the *critical synthesis* of selected theoretical work, namely [Falkenberg et al., 1998, Frank, 2011b, Hoppenbrouwers et al., 2005b, Kaschek, 2013, Mahr, 2009, 2011, Proper et al., 2005, Rothenberg, 1989, Stachowiak, 1972, Thalheim, 2012, 2013, von Braun et al., 1999, Wyssusek et al., 2001a,c]. The proposed fundamental view on modelling combines the grounding in cognitive sciences and semiotics. While *coherent* with the existing body of knowledge, this framework contributes by explicitly considering the notion of *model purpose*, as well as its influence within the *modelling process*.
- **A fundamental view on the role of conceptual modelling language**, building on the proposed view on modelling. We identify a twofold function of conceptual modelling language, namely *linguistic* and *representational* function. The understanding of linguistic function is *grounded* in functional linguistics [Clark, 1993, Cruse, 2011], cognitive linguistics [Geeraerts, 2010], and cognitive science [Baddely, 2012, Lakoff, 1987, Winograd and Flores, 1986].
- **An explanatory theory**, formulated based on the above-mentioned theoretical contributions, and refined based on the empirical evaluation within an interpretive field study [Klein and Myers, 1999], and through the use of qualitative data [Miles and Huberman, 1994]. This theory focuses on the linguistic function as the most important source of variation

of modelling languages. While it may not be the only source that triggers the ‘dialectisation’ in the actual use of a modelling language, the linguistic function is the least theoretically understood, and the least supported in the actual language engineering efforts.

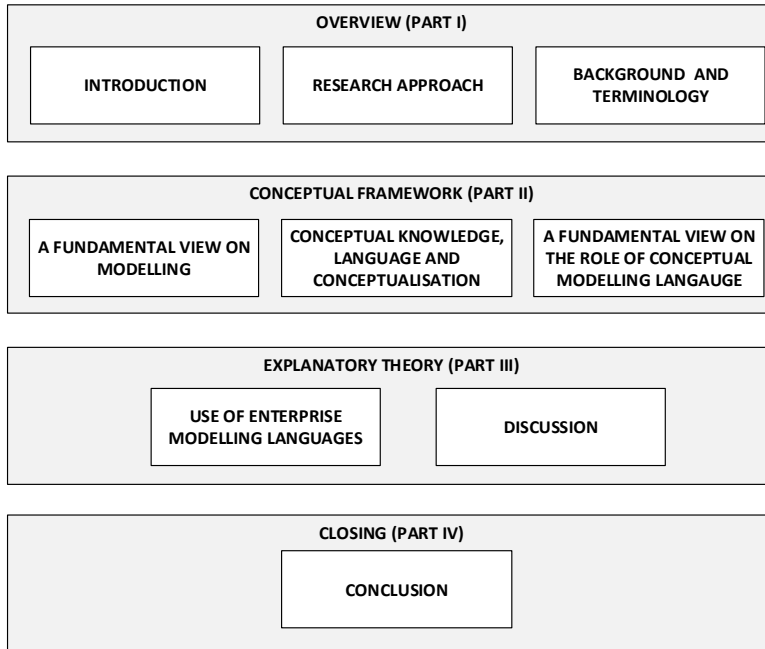


Figure 1.2: Thesis structure

The relationships between thesis contributions and formulated research questions are portrayed in the Figure 1.1.

1.6 Thesis Structure

The research conducted in the thesis is reported according to the structure illustrated in Figure 1.2. First of all, a high-level *Overview* of this thesis, besides the present introductory chapter, discusses the adopted research approach (Chapter 2), and introduces relevant background terminology (Chapter 3). In the part *Conceptual Framework*, we elaborate the theoretical contributions on modelling (Chapter 4) and the role of conceptual modelling language (Chapter 6). The latter contribution uses the reference knowledge from the cognitive-linguistic disciplines, which is introduced in Chapter 5.

The part *Explanatory theory* discusses the proposed explanatory theory and its empirical evaluation (Chapter 7), followed by the discussion of its implications and limitations (Chapter 8). We reflect on the conducted research and open potential future research perspectives in the *Closing*.

CHAPTER 2

Research Approach

The research subject of this thesis is studied from the stance of **socio-pragmatic constructivism (SPC)**, as formulated by [Wyssusek et al., 2001a, 2002]. The choice of this paradigm is influenced by the *nature of our research subject*, and an inherently *pragmatic orientation* on the phenomena of modelling adopted in our research.

In this Chapter, we justify our choices of philosophical stance and of the research methods used. In Section 2.1, we discuss the ontological and epistemological position of SPC, and justify the reasons that guided its adoption for the study of our selected research subject. Thereafter, Section 2.2 briefly revisits the basic postulates of scientific theory and scientific explanation, as they relate to our primary objective of developing explanatory theory. Finally, Section 2.3 elaborates on the adopted research approach and its underlying methodological considerations.

2.1 Philosophical Stance

As a paradigm of inquiry, SPC is inspired by the philosophies of Kant and Heidegger [Wyssusek et al., 2002], and stands as a middle-way between the paradigms of *positivism* and *radical constructivism*.

Ontological position. The ontological position of SPC is a *relativist* one: *reality is considered as neither objective nor subjective, it is rather a construction* which results from the interaction between socially contextualised humans and their environment, by means of shared language and common practices [Wyssusek et al., 2001a, 2002]. “[T]he very idea of *construction* within Sociopragmatic Constructivism has to be understood in the sense of a socially, pragmatically oriented description of inter-subjective processes, within which

humans create, stabilize, share and modify their knowledge. Paying regard to these practices of cultural involvement and knowledge acquisition one will realize that they are no solipsistic acts of a sole individual, but common structures of purposes and needs, guiding all human activity.” [Wyssusek et al., 2002, p. 834].

Epistemological position. SPC embraces the view that human cognition is socially and culturally situated. In other words, “since the ontology is epistemically bound, the process of reality construction (ontology) and cognition of reality (epistemology) have to be considered as one and the same” [Wyssusek et al., 2002, p. 834]. Therefore, opposed to positivist orientation, in SPC *knowledge* “can no longer be regarded as an entity, but is rather bound to an individual within its particular social context, thus defying any direct manipulation” [Wyssusek et al., 2001b, p. 772]. Additionally, and as a criticism of radical constructivist epistemological stance, SPC epistemology does not assume “an isolated subject perceiving or constructing objects, but a common, socially shared construction of world, objects and subjects” [Wyssusek et al., 2002, p. 834]. Consequently, knowledge is never considered as objective in the positivist sense, rather the relative objectivity of knowledge arises as quality of being grounded in a social consensus within a relevant group. When the consensus no longer exists, the relative objectivity of knowledge is to be questioned.

Language, knowledge and cognition. Within this paradigm of inquiry, language and common practices are considered as having a central place in our encounters with the world and our cognition of it. Common practices are realised on the basis of symbolically constituted worlds of meaning (Sinnwelten) [Wyssusek et al., 2001a, p. 191], while “the play of language [that] structures our (symbolic) world” [Wyssusek, 2004, p. 4305]. Common language is therefore intimately linked to and grounded in common practices, i.e. communities of practice, as it is “only in such communities that objectifications by means of language develop a stable yet not fixed meaning that enables the members of respective community to communicate effectively and efficiently.” [Wyssusek, 2004, p. 4307]. Different communities thus imply different ‘realities’ and languages [Wyssusek et al., 2002], the position that comes close to the weak formulation of *linguistic relativism* [McAfee, 2004, Pederson, 2010, Tohidian, 2009].

“If language is so closely knit to our experiences it comes as quite natural to understand language as a means of representation of our experiences. Yet, there is another feature of language we have to take into a consideration: The meaning of linguistic expressions is not fixed; symbols are multivalent. In short, we use the same expression to express different meanings. Quite often objectification has been confused with objective meaning of linguistic expression” [Wyssusek, 2004, p. 4305]. The essence of symbols rests in the *transcendence* of relation between the symbol and the object symbolised, “which is neither a property of the symbol representation nor of the referent. It is a capability unique to humans that enables them to establish a reference between something present and something not present.” Wyssusek et al. [2001a, p. 191].

We argue that the stance of SPC with its orientation on knowledge and language is more appropriate for studying our research subject than traditional positivist assumptions upon which the normative perspective on modelling languages rests. The assumptions of SPC regarding human cognition, knowledge, and the role of language in these processes are in line with the central orientation of our research, which aims to develop an understanding of modelling language use *in relation to the objectives and constraints of a socio-pragmatic modelling context*. We consider the value of a modelling language as inherently related to its use [Bjeković et al., 2014a], and are interested in better theoretical understanding of the nature of knowledge carried by engineered languages, as well as its interaction with a specific modelling context. The traditional normative orientation on modelling languages focusses more narrowly on the isolated study of syntactic-semantic code, and in our view is not adequate for the study of our research subject. More fundamentally, a purely normative orientation on modelling languages denies the principles of socio-cognitive functioning of human languages [Wyssusek et al., 2002], and stands in opposition with the inter-subjective nature of conceptual knowledge [von Braun et al., 1999, Wyssusek et al., 2001a]. Therefore, the choice of the SPC stance is also motivated by the need to go beyond the positivist understanding of knowledge and language, often adopted in the studies of design and evaluation of conceptual modelling languages.

2.2 Theory and Scientific Explanation

In the thesis, we target an *explanatory theory* as the primary research objective.

While an indisputable and unified view of what makes a scientific theory is still debated [Bichler et al., 2016, Frank, 2017, Grover et al., 2008]), the essential **principles or postulates of a scientific knowledge** can serve as guidance.

For instance, Grover et al. [2008] emphasise *conceptual rigour* and *forward looking* orientation of the theory as critical requirements for developing scientific theories in the IS field. While rigour refers to the quality of development of theoretical components, the forward looking orientation of the theory refers to the boldness and innovativeness of theoretical propositions with regards to the existing knowledge and established theoretical beliefs.

Similarly, Frank [2006, 2017] emphasises that scientific knowledge is characterised by three essential postulates of *originality*, *abstraction* and *justification*. *Abstraction* refers to the requirement that scientific knowledge should go beyond describing specific instances, and should focus on uncovering generalities and patterns applicable to a whole range of situations. Abstraction can refer to both actual and possible worlds. *Originality* refers to the claim of novelty of the knowledge contribution, as well as its superiority with regards to the existing knowledge. *Justification* refers to the evidence for truth of the corresponding theoretical propositions.

Next to these postulates, the scientific knowledge is also characterised by a clear communication of its key elements: *motivation*, *constructs and propositions*, and *boundaries or application scope* [Frank, 2006, Grover et al., 2008, Whetten, 1989].

The **explanatory theory** specifically aims at scientific understanding and explanation of some phenomena of interest, typically in terms of relations of (different degrees of) causality/correlation between (independent and dependent) variables pertaining to the studied phenomena. In the context of our theory development, as well as the adopted philosophical stance, we acknowledge that a scientific explanation is not to be considered as an absolute one in the positivist sense [Klein and Myers, 1999]. Therefore, the scientific explanation we aim for is not developed based on a "statistically representative" sample, but the constructs and propositions developed are considered as a "sensitizing device" [Klein and Myers, 1999] to view the world in a certain way. Therefore, the explanation in terms of independent and dependent variables and their relationships is not based on statistical generalisation, but analytic generalisation, and its quality depends on the plausibility and cogency of reasoning applied [Klein and Myers, 1999, Miles and Huberman, 1994]. This implies the necessity to be explicit about assumptions and conditions on which the explanation relies, as well as the contexts in which the explanation holds.

2.3 Method Pluralism and Adopted Research Approach

In developing the explanatory theory, we combine an analytic and an interpretive approach, and also rely on the guidance provided by the proposition of *method pluralism* [Frank, 2006] for IS research.

2.3.1 Method Pluralism

The framework for method pluralism is motivated by the appreciation of limitations of a single research method/approach for addressing the variety and multidisciplinary of topics in IS as a research field. To this end, [Frank, 2006] offers the conceptual and methodical framework to enable and guide the configuration of different research methods in a research project. In the following, some the key concepts underlying this proposition, as illustrated in Figure 2.1, are briefly summarised.

Theories of Truth and Justification

While scientific contributions come with a claim for truth, the notion of truth is dependent on the adopted epistemological and ontological assumptions. Accordingly, one may prescribe to *correspondence*, *coherence* and *consensus theory of truth*. Namely,

- *Correspondence theory of truth* "is usually related to critical realism: It assumes that a correspondence between a proposition and the described

taken from [Frank, 2006, p. 43]
 A theory application is aimed at explaining a phenomenon by applying a theory that was originally created to other domains. In other words, it is aimed at extending the domain, the theory can be applied to. This requires projecting/adapting the propositions of the theory to the studied subject. It is supplemented by testing the truth of these propositions. Conceptual frameworks are an important part of research, both with respect to abstractions of the factual and abstractions of the intentional. They provide the abstractions that serve to conceive of and to structure the research subject. In other words: They provide the concepts that serve as core instruments for scientific recognition and its dissemination. Giddens underlines the pivotal relevance of conceptual frameworks especially for the social sciences.

words. They provide the concepts that serve as core instruments for scientific recognition and its dissemination. Giddens underlines the pivotal relevance of conceptual frameworks especially for the social sciences:

“*Coherence theory of truth*” suggests that a proposition is true, if it is consistent with an existing set of accepted (“true”) scientific and colloquial “propositions” [Frank, 2006, pg. 14]. The potential new knowledge is tested for its coherence with the accepted coherent body of knowledge. The discovery of ‘laws’ is only one concern among others that are equally important to the theoretical content of social science. Chief among these other concerns is the provision of conceptual means for analysing what actors know about why they act as they do ...” [Giddens, p. xix]

its shortcoming is that it does not allow space for a knowledge contribution that is not compliant with the existing convictions.

[illegible]

pg. 15].

While the choice of theory of truth is typically related to the field of research one is situated in, Frank [2006] proposes that their combination can be fruitful, in that it can allow overcoming their respective individual limitations and weaknesses, and strengthening the justification of a research contribution.

The *justification* of a scientific contribution, as well as procedures for testing the truth, are dependent on the concept of truth adopted.

- “Only if they are applied with a sceptical attitude towards their inherent limitations, they comply with the idea of science.
- Apparently, the theories of truth do not mutually exclude one another. Combining them can help with overcoming specific weaknesses and hence may contribute to a more appropriate, multi-perspective concept of truth” [Frank, 2006, pg. 15].

Research Method and Knowledge Contributions

According to [Frank, 2006], the research method should provide the concepts to structure the research projects, and the process to guide their realisation [Frank, 2006]. The following core concepts of research methods are proposed:

- *Generic epistemological contribution* includes construction and critique. *Construction* is focussed on creating new knowledge, and uses concepts to develop theories or interpretations. The notion of construction emphasises that there is always the need for developing concepts to express new knowledge on a higher level of abstraction. On the other hand, *critique* is aimed at challenging or evaluating given knowledge contributions. It usually includes the constructions that substantiate the intended judgement.
- *Abstract and concrete knowledge contribution* are illustrated in Figure 2.1 with the explained colour coding. *Abstract knowledge contributions* are special cases of construction and critique. Frank differentiates between two types of constructions: *abstraction of factual*, which is aimed at superior description of the factual world, and *abstraction of intentional*, which targets interesting possible worlds. Accordingly, critique can target both types of constructions, which is depicted in the Figure 2.1. Possible *concrete knowledge contributions* are enumerated in the figure as special cases of abstract knowledge contributions.
- *Representation of the knowledge contribution* is achieved through language, which can range from natural, semi-formal to formal. As language lies at the core of scientific research, it is widely agreed that the language used in scientific research should be as precise as possible.
- *Justification criteria* refers to selecting and/or combining the preferred theory of truth, and procedures to justify (i.e. provide scientific evidence

for) the knowledge contribution. Frank argues that while the notion of truth is adequate for abstractions of factual, the notion of adequacy is more appropriate as justification criteria for the abstraction of intentional.

- *Justification procedure* for a specific knowledge contribution is then to be selected in accordance with the selected theory of truth, as exemplified in Figure 2.1.

2.3.2 Research Methods Used

Relying on the method pluralism proposal, the research approach we adopt combines analytic and interpretive approach in developing the explanatory theory. This is illustrated in Figure 2.3. The present section focuses on the justification of the adopted combination of approaches, while the detailed methodological considerations of each individual contribution of the thesis (Figure 2.3) are discussed in their corresponding chapters.

According to Klein and Myers [1999], interpretive research focuses on the complexity of human sense making within context, and acquires the explanation through the meanings assigned by people. Based on hermeneutics, interpretive research seeks to understand “a moving target” [Klein and Myers, 1999] and, the knowledge gained about the phenomena of interest will always be related to the context. For the phenomena of our interest, we believe its observation and interpretation throughout a sustained period of time, and within its ‘natural’ context is crucial. We work based on the assumption, reified in our theoretical framework, that reasons and factors contributing to the particular use and adaptation of a modelling language can only be understood and explained in relation to the context, i.e. particular modelling effort as situated in its context and with all its constraints. For these reasons, we opt for the *interpretive approach*, and rely on the guidelines of [Klein and Myers, 1999].

However, we appreciate that the present thesis aims to provide a new theoretical perspective on the subject of modelling language use, but the subject itself is not new. In other words, there is already an existing body of knowledge in the fields of conceptual/enterprise modelling, which we draw upon, reflect on, and justify required refinements in relation to our research subject.

Therefore, the concepts used in developing explanatory theory are built using the *analytic approach*, and the propositions developed are refined through an interpretive field study. Consequently, the interpretive field study has both a *confirmatory and revelatory role* with respect to the explanatory theory:

- First, it serves as additional material for refining theoretical reflection, at the same time acting as the controlling instrument with regards to the breadth and depth of theoretical development. This means that the theoretical basis is not held firm throughout the field study. Consequently, by means of empirical observation, we also indirectly gain feedback on the base theories underlying the explanatory theory.

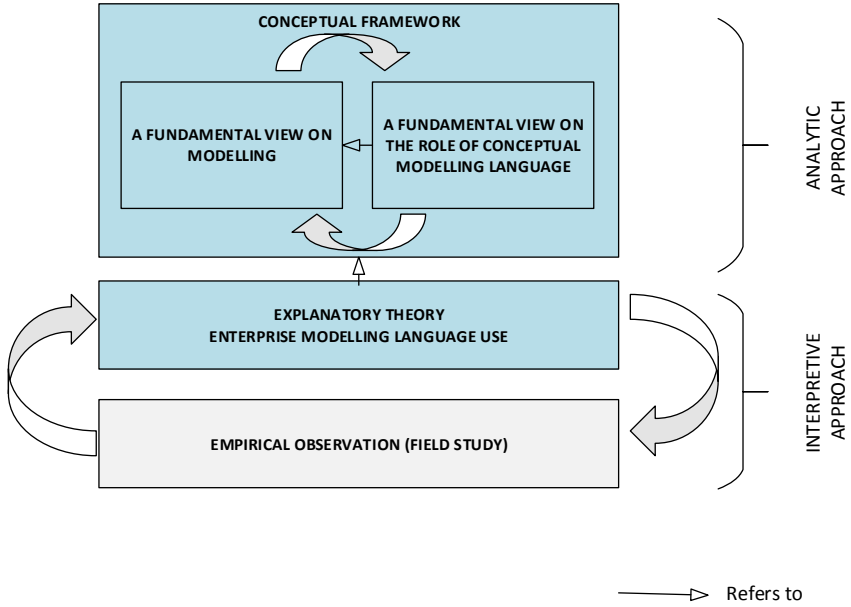


Figure 2.2: An overview of the adopted research approach

- Secondly, the field study also allows to operationalise the factors affecting modelling language use that relate to the identified linguistic and representational function. Finally, it also allows to offer an initial theoretical reflection regarding the emergence of a modelling language dialect-like variant in general, as well as in particular cases. The feedback from our empirical observation is thus to be taken as a *preliminary evaluation* of the explanatory theory.

This configuration naturally implies an incremental and iterative research process, as illustrated in Figure 2.2. Both constituents of the conceptual framework on modelling mutually influenced each other's refinement, while explanatory theory is revised and refined through the interpretive field study.

Analytic Approach

We use an **analytic approach** to develop the *conceptual framework* which formulates a fundamental view on models, modelling and the role of conceptual modelling language maintained in the thesis. This conceptual framework is developed using *deductive reasoning*, and combines the *coherence and consensus theory of truth* [Frank, 2006]. As depicted in Figure 2.3, this framework consists of two components:

- First, a fundamental view on models and modelling, as a result of the

critical synthesis of the selected related work (*coherence theory of truth*). It formulates our definition of a model and the high-level view on the modelling process, and is elaborated in Chapter 4.

- Secondly, the proposed view on modelling is the basis for the proposition of a twofold role of a conceptual modelling language, developed combining *coherence theory of truth* and *consensus theory of truth*. This view, elaborated in Chapter 6, proposes to study the use of conceptual modelling language based on its twofold function in modelling, namely *linguistic function* and *representation function*. While representation function is in the focus of modelling language studies in the current research, what we refer to as linguistic function is far less understood and taken into account in the study and design of conceptual modelling languages. In the thesis, we build the understanding of linguistic function which is *grounded* in the *reference disciplines* of functional linguistics [Clark, 1993, Cruse, 2011], cognitive linguistics [Geeraerts, 2010], and cognitive science [Baddely, 2012, Lakoff, 1987].

Interpretive Approach

The above-mentioned contributions constitute the conceptual framework for formulating the explanatory theory, whose hypotheses are confronted to, and further refined through, the *interpretive field study*. In this context, we rely on the *correspondence theory of truth* [Frank, 2006].

Within the interpretive field study, we perform qualitative analysis relying on the guidelines of *qualitative data analysis* by [Miles and Huberman, 1994]. The choice to work with qualitative data is related to the potential of qualitative data to allow for deeper and richer understanding of the phenomena. According to [Miles and Huberman, 1994], the use of qualitative data offers the potential to reveal complexities and subtleties that are rather not available in other modes of data collection.

To the best of our knowledge, most of the available empirical reports addressing the use of modelling languages, result from surveys and interviews with selected respondents groups. These surveys and interviews seek for generalised reflections of the respondents, across different modelling experiences, and at a period of time distant from the actual events of modelling language use. This prevents an in-depth exploration of the concrete circumstances of a single modelling effort, and significantly reduces the quality of data collected: the data is limited to what is remembered by the respondent, does not allow the insight into models and documentation created, decisions taken and its underlying reasons, etc. Furthermore, the data collected this way is usually analysed using quantitative methods, as in e.g. [Anaby-Tavor et al., 2010, Malavolta et al., 2013, zur Muehlen and Recker, 2008], and is focussed on ensuring generalisability over a statistically representative sample. However, a deeper understanding and explanation of what leads to it is still lacking in the literature. For this reason, we argue that an interpretive field study working with qualitative data may be a more appropriate approach for confronting and refining our theoretically constructed explanatory hypotheses.

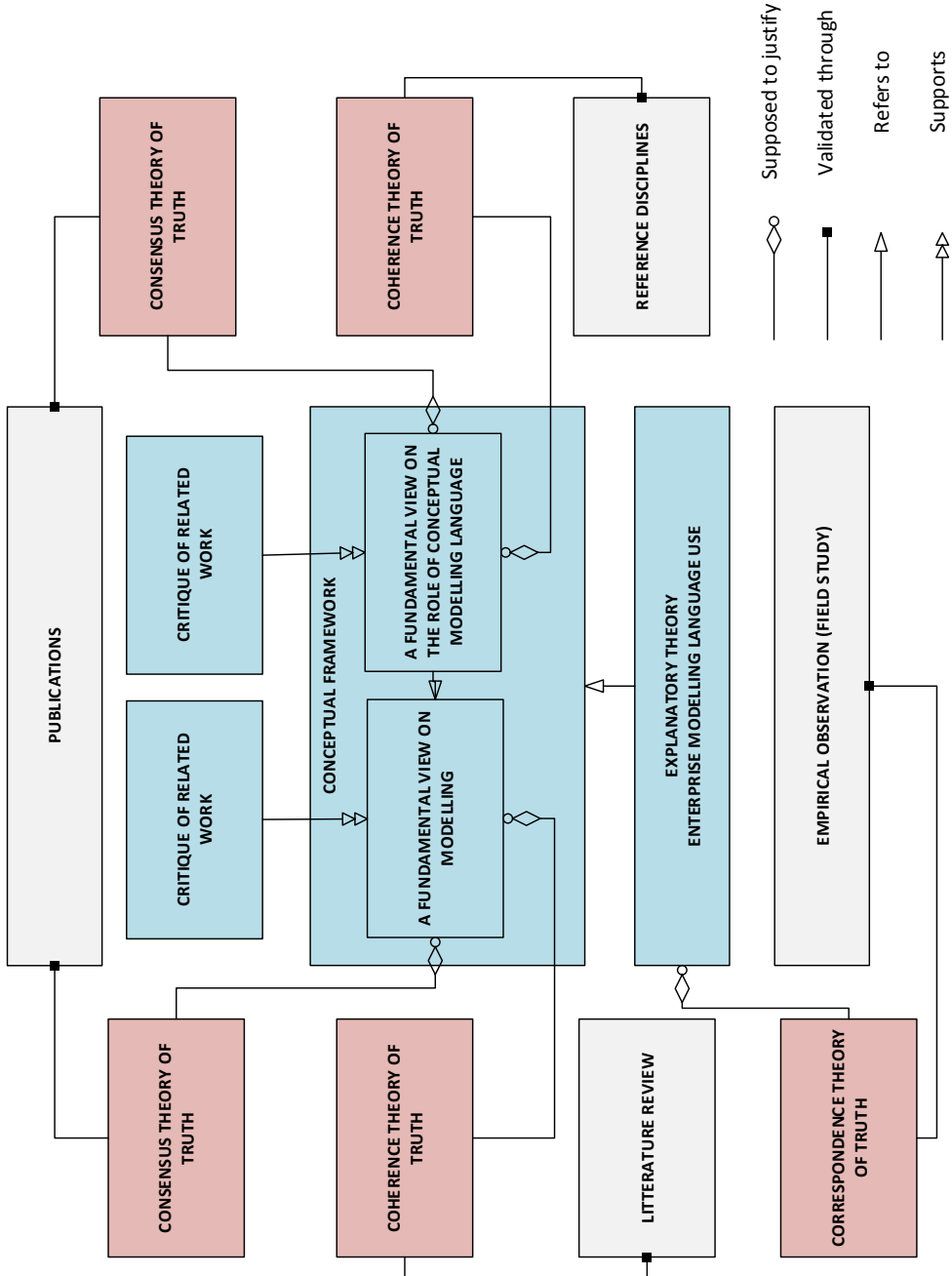


Figure 2.3: Configuration of the adopted research approach, structured and presented in accordance with the conceptual model underlying method pluralism proposal [Frank, 2006, p.43]

2.4 Summary

In this chapter, we have discussed and justified the ontological and epistemological assumptions adopted in conducting our research, as well as portrayed the methodological framework which guided our configuration of the research approach. Finally, we explained and justified the adopted research approach, and discussed the relationships between the individual thesis contributions.

CHAPTER 3

Background and Terminology

The use of signs lies at the core of human experience. They are vehicles by means of which physical artefacts are used to create, sustain, alter and ‘use’ the world we live in, and are inextricably created to language. While traditionally, in computer science, languages were considered primarily from the perspective of their formal organisation, it may also be appropriate to understand languages and how they function from the perspective of how they are used in everyday life by people. In this context, the present chapter deals with the basic terminological background relative to the study of signs (Section 3.1), language (Section 3.2) and modelling languages (Section 3.3).

3.1 Signs and Semiotics

In general, signs are understood as something that stands for something else in some quality. However, the notion of sign involves more subtleties than portrayed in this general characterisation. In the following, we will look in the two widely known characterisations of the sign notion.

3.1.1 Different Sign Notions

The **dyadic sign notion**, illustrated in Figure 3.1, developed within the semiology of Ferdinand de Saussure, is known as a classical notion of sign. For Saussure, the sign is characterised as two-part, i.e. dyadic, entity, consisting of a material signifier (*signifiant*), i.e. that which is used to signify, and that which is signified (*signifié*). Such characterisation, which is due to Saussure’s background in linguistics of the time, leaves out of the consideration how signs stand in relation to the world.

Peirce’s semiotics introduces the notion of interpretant in the characterisation of signs’ nature. Unlike its common interpretation as a **triadic sign**

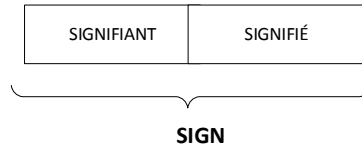


Figure 3.1: Sign as diadic notion, according to Saussure.

notion (e.g. in [Falkenberg et al., 1998]), Peirce’s semiotics defines *sign*, not as a three-part entity, but rather as part of a **triadic relationship of signification** Short [2007]¹.

Sign, according to Peirce, is something which stands to somebody (*intepretant*) for something (*sign’s object*) in some respect or capacity. *Interpretant* is considered very broadly, as a feeling, a thought, or an action by which or in which a sign is interpreted.

Therefore, sign, sign’s object and interpretant *and* their being in a triadic relationship to each other make the signification possible. That is the the essence of signification as a *triadic* relationship. Furthermore, mature Peirce recognises that signification occurs in the context of purposeful action². This is illustrated in Figure 3.2. Therefore, in one signification context, the three above-mentioned elements stand in a triadic relationship. Within a different context, the same three elements may potentially stand in a very different triadic relationship, and hence be in a different signification.

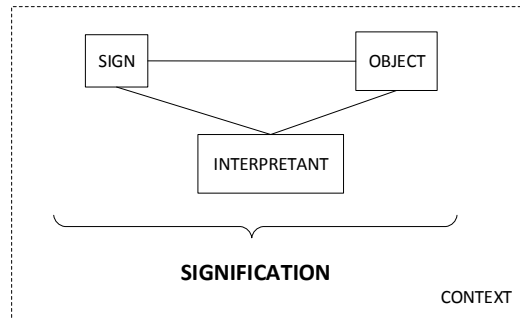


Figure 3.2: Peirce’s notion of sign as part of triadic relationship of signification, according to [Short, 2007].

¹Although [Short, 2007] mentions that Peirce uses the term *significance* instead of *signification*, we hereby choose to use the latter term for the same concept, to avoid the potential confusion with the common meaning of significance – importance.

²“*Outside of purposeful action, which appears to be limited to animals, no mistakes are possible, and where no mistakes are possible, there can be no intentionality, hence, no interpretation; but all significance is relative to potential interpretation.*” [Short, 2007, p. 177]

This – not so widely known – understanding of Peirce’s sign notion and nature of signification implies that the ‘reference’ between sign and its object cannot be given independently of the interpretant and context of purposeful action. In our work, the adopted philosophical stance of SPC (Chapter 2) indeed implies this understanding of signs (thus also languages and modelling languages), and takes the context of purposeful actions as the basis for establishing the relationship of signification. This indeed is one of the central tenets of Wyssusek’s development of SPC paradigm (Section 2.1): “The very essence of a symbol rests in the transcendence of this relation [...] It is a capability unique to humans that enables them to establish a reference between something present and something not present” [Wyssusek et al., 2001a, p. 190].

3.1.2 Symbols, Icons and Indices

Peirce’s distinction of icons, indices and symbols is introduced as them being *mutually non-exclusive qualities* of signs [Short, 2007]:

- **Icons** are signs that signify in so far as they mirror qualitative features of the object it stands for. Typical examples of iconic signs are portraits and paintings.
- **Index** are signs that signify due to their existential or physical connection to the object they stand for. In this context, the signification of an index sign would no longer be possible if the object it stands for stopped to exist. For instance, typical indices are natural and causal signs, finger pointing, names, smoke (stands for fire), etc.
- **Symbols** are, according to Peirce, defined as those sign-vehicles that use some convention, habit or social law/rule for the successful determination between the sign and its object [Short, 2007]. Social conventions and laws play a crucial role in the signification process; a mere signal or token is not a fully developed sign unless it functions at the social level. Typical examples of symbols are words in natural language.

For Peirce, any sign may actually demonstrate any combination of these qualities at the same time. In other words, iconic, indexical, and symbolic qualities can be found in one single sign, and that in reality it is hard to find any pure instance of indices and icons [Short, 2007]. For instance, natural language signs are typically considered as being of symbolic nature, but it is noteworthy that many of such signs also have iconic qualities (e.g. metaphors [Lakoff and Johnson, 1980]) or are of indexical character (e.g. pronouns, spatial and temporal adverbials).

3.1.3 Semiotic Study of Signs

The study of signs is the focus of **semiotics**, a discipline emerged from philosophy. The distinction of layers of study of signs in terms of *syntax*, *semantics* and *pragmatics* goes back to Morris [Morris, 1946], as well as Peirce’s philosophy of pragmatism [Allwood, 1981, Short, 2007].

According to [Allwood, 1981], the traditional distinctions of these layers are outlined in the following manner:

- **Pragmatics** is defined as the study of origins, use and effects of signs.
- **Semantics** is defined as the study of signification in all modes of signifying.
- **Syntax** is defined as the abstract study of the relationship between signs *without* taking either their signification, origin, use or effect into account.

Allwood [1981] discusses that in the previous versions of Morris's work, the semantics was more narrowly defined as concerned with the abstract study of relationship between signs and the object they signify, leaving out the role of interpretant. This focus was, however, widened in the later version of Morris's work, coming more in line with the Peirce's interpretation of signification.

3.2 Natural Language and Linguistics

Language is generally defined as a *system of signs*, which defines signs and rules for their combination, governing the creation of meaningful expressions.

Natural language signs are predominantly of symbolic nature, and, indeed, natural language is also often defined as a *system of symbols*, given that their signification is grounded in conventions, habits, and patterns of action within corresponding speech communities.

While semiotics studies signs and signification in general (language being but one of sign systems), *linguistics* is specifically concerned with the study of natural language. Within linguistics, the study of language is, generally speaking, also devised in terms of *syntax*, *semantics* and *pragmatics*. Depending on the perspectives on the object of study adopted in different branches of linguistics, the consideration and relative importance of these aspects of language varies.

Hereafter, we briefly outline some of the main traditions of linguistic study, which are of particular interest for our purposes (See Chapter 5). We will base ourselves on a broad distinction between *formalist* and *functionalist* orientation to the phenomena of natural language. In addition, we will discuss in particular the central tenets of a *cognitive orientation* as sub-set of functionalist approaches to language, given that cognitive linguistics plays an important role in the thesis.

3.2.1 Formalist Orientation in Linguistic Studies

The formalist orientation on natural language draws in general on the objectivist paradigm within analytic philosophy³, and studies natural language as a formal system. Within this tradition, human thought is basically equated to

³The representatives of this kind of thought are, for instance, Descartes, Pascal, Russell, Quine, young Wittgenstein, with extreme examples in Frege and Plato [Geeraerts, 2010, Lakoff, 1987].

manipulation of abstract symbols, whereas the primary purpose of language is considered to be an objective description of the world.

Syntax/grammar is in the main focus of formalist approaches to language. Syntax deals with the system of rules for symbol combination, which constrain meaningful language expressions. In particular, Chomskyan generative linguistics emphasises grammar as the main preoccupation of linguistic studies, whereby grammar is studied as autonomous from semantics⁴.

Semantics is studied based on the notion of reference and formal truth. Conceptual categories in natural language are considered as abstract, and separate from human experience, taking typically form of classical categories. They get their meaning via reference to the objectively existing categories and entities of the real world. All the non-referential and context-dependent aspects of linguistic meaning, basically all aspects falling out of the formal conception of language, are classified into *pragmatics*. As source of subjectivity, vagueness and error, pragmatics was considered uninteresting for theoretical language studies.

3.2.2 Functionalist Orientation in Linguistic Studies

In contrast to formalist views, functionalist orientation on language adopts the working hypothesis that linguistic structure cannot be analysed and explained independently from its use, i.e. that linguistic structure originates from and is motivated by its use. Rather than an objective description of the world, the primary *raison d'être* of language is considered to be framing thought and communicating experiences. Therefore, the linguistic structure and meaning are studied in this communicative capacity.

Functionalist approaches to language situate human linguistic capacity within more general capacities of (the rest of) human cognition. Drawing on that assumption, and in opposition with generative linguistics, grammar and conceptual systems (semantics) are considered as interconnected. Furthermore, as *language use* is within this tradition considered as an essential part of linguistic meaning (e.g. [Allwood, 1981, Clark, 1993, Cruse, 2011]), the distinction between semantics and pragmatics becomes rather an obstacle to insightful study of language: “[...] we have no theoretically interesting and consistent way of separating semantics from pragmatics and that perhaps the distinction is more of a hindrance than an aid to clarity in the study of meaning in natural languages. Perhaps, it would in fact be better to abandon the distinction in favor of a semantico-pragmatic approach where linguistic meaning has as its primary function contextual adaptability, which would make such things as vagueness, metaphor and contextual determination of meaning central concerns rather than phenomena which are seen as exceptional and therefore safely left for another day” [Allwood, 1981, p.188].

Within the family of functionally-oriented approaches to language, it is possible to differentiate between more *functional* as opposed to more *cognitive*

⁴Generative linguistics is based on the idea of language being a separate modular system within human brain, which is autonomous of the rest of human cognitive system, and somehow innate [Geeraerts, 2010, Lakoff, 1987].

focussed approaches [Nuyts, 2010]. According to Nuyts [2010], this distinction consists mainly in the difference of focus, and to some extent also to different conceptions of grammar and its motivation. The more *functional* approaches are primarily interested in communication capacity of language, and study many of the factors affecting structuring and use of language in different communicative contexts (e.g. [Clark, 1993]). The predominant focus is the account of linguistic structure, and syntax is still conceived as the system of rules to be applied by a speaker when composing utterances. Conversely, the more *cognitive* oriented approaches focus primarily on the account of conceptual–semantic dimension of language, and study the cognitive underpinnings of language. Grammar studies within this branch are influenced and informed by the study of semantic constructions [Lakoff, 1987, Langacker, 1987, 1991]: conceptualisation is seen as central to linguistic structure, and grammar basically captures usage-based patterns of forming conceptualisations.

3.2.3 Cognitive Orientation in Linguistic Studies

Cognitive linguistics [Geeraerts, 2010, Lakoff, 1987, Langacker, 1987, 1991] is the main representative of more cognitive approaches within the functional family of linguistic theories.

Drawing on advances within cognitive science and cognitive psychology, it studies natural language as being structurally and functionally continuous with, *socially and culturally situated cognition* [Geeraerts, 2010]. This position is in line with the SPC stance adopted in the thesis.

Compared to other functional approaches, cognitive linguistics focuses on semantics as central language phenomenon. It studies language as an instrument for organising, processing and conveying experiences and knowledge of the world. Thus, the knowledge of the world, as reflected in language, is considered from a non-objectivist, experientialist, position: Rather than being disembodied, the phenomena of knowledge and language are both considered within cognitive linguistics as being intimately linked to human experiences in different speech communities, i.e. *knowledge and language are understood as having experiential basis* [Geeraerts, 2010, Lakoff, 1987]. Furthermore, all the linguistic structure, including grammar, is studied as arising and interacting with the actual usage of the language.

While considering semantics and syntax as interconnected, unlike other functional approaches, cognitive linguistics gives semantics a central place in the architecture of grammar [Lakoff, 1987, Langacker, 1987, 1991]. With a dominant preoccupation on semantics in language studies, cognitive linguistics considers categorisation as a primary language function of language, and focuses on clarifying its cognitive underpinnings, as well as experiential influences.

3.3 Languages for Modelling

The basic understanding of the nature of signs, signification and language is relevant in modelling, as the process of model creation is inherently a *semiotic* process. When creating a model, one can theoretically use any artefact (residing

in physical space) as a *sign*⁵ when creating a model. Typically, however, the choice of signs to use in the context of conceptual modelling is constrained by a *modelling language*.

Traditionally, in computer science, *modelling languages* are conceived as basically extensions of expressions in logics, which explicitly define signs and constrain their allowed combinations. For instance, Karagiannis and Höfferer [2006] propose to distinguish between *non-linguistic* and *linguistic models*, as “non-linguistic or iconic models use signs and symbols that have an apparent similarity to the concepts of the real world that are being modeled” [Karagiannis and Höfferer, 2006], whilst linguistic models use primitives that “do not contain any apparent relationship to the part of reality being modeled except the one that is defined in an explicit way” [Karagiannis and Höfferer, 2006]. This traditional view which focusses mainly on formal organisation of the language stems from formal language theory and computer science. It is concerned with allowing the mechanical manipulations of representations. Next to mechanical manipulation of models, there are additional considerations for modelling languages in the context of conceptual and enterprise modelling. In conceptual modelling, mainly targeted at development of information systems, the requirement to account not only for machine-oriented use, but also human users of models (especially stakeholders), creates some conflicting requirements to take into account in language engineering.

Within enterprise modelling, with “more specific and at the same time a wider scope” [Frank, 2011b, p. 41] than conceptual modelling. On one side, the complexity of an enterprise as a phenomenon which is subject to modelling requires a wide range of perspectives, stakeholders and purposes to be taken into account. Next to this, a particular relevance of language for communication, collaboration and change in enterprises adds puts more tension to the requirements regarding languages to be created for enterprise modelling.

3.3.1 Elements of Modelling Language Definition

Traditionally, a *modelling language* is typically considered as system of symbols and rules of their combination, which restrict the set of models representable in the modelling language [Falkenberg et al., 1998, Harel and Rumpe, 2004, Karagiannis and Höfferer, 2006]. Based on such an orientation, modelling languages are defined in terms of abstract syntax and semantics [Harel and Rumpe, 2004]. Additionally, the proliferation of graphical/diagrammatic modelling languages in conceptual modelling and enterprise modelling, the aspect of concrete syntax [Karagiannis and Höfferer, 2006] also becomes of particular interest.

The **abstract syntax** of a modelling language defines the modelling constructs and rules for their combination. For graphical modelling languages, abstract syntax is usually expressed using meta-models⁶.

⁵The sign used may even have its ‘primary function’ very different from the function they are attributed to in modelling. For instance, graphics, or tangible objects such as pen, pebble, cup of coffee can serve as signs in the process of model creation [Zarwin et al., 2014]

⁶Favre [2006] discusses that meta-model is a slippery notion, while advantages or disadvantages of using meta-modelling for representing abstract syntax are discussed in e.g. [Harel

The **semantics** of a modelling language is traditionally considered as dealing with the meaning of modelling constructs, and is defined in terms of *semantic domain* and *semantic mapping* [Harel and Rumpe, 2004]. According to [Harel and Rumpe, 2004], the semantic domain captures the “decisions about the kinds of things language should express” [Harel and Rumpe, 2004, p. 68], while the semantic mapping establishes the correspondence from (abstract) syntactic elements to the semantic domain.

However, this perspective on modelling languages and their definition emerged from formal language theories, and clearly separates syntactic and semantic phenomena in language definition. However, in the case of conceptual modelling language, its metamodel provides a particular conceptual foundation, i.e. a specific classification of concepts to be used in discourse about the world. Falkenberg et al. [1998] argue that this is a crucial element of the modelling language, and that all other elements depend on it. Along the same lines, Frank [2011b] considers that influence of natural language ‘labels’ in (abstract syntax elements) cannot be disregarded in the discussions of modelling language semantics. Based on previous discussions on signs and language, we can also say that the entire signification context cannot be disregarded either.

The **concrete syntax** or *notation* deals with the representation of modelling constructs on a physical medium⁷. The separate consideration of concrete syntax and abstract syntax is considered of interest because it allows these two to (theoretically) be replaced independently from each other [Karagiannis and Höfferer, 2006], or also to allow for multiple visualisations of modelling constructs, depending on e.g. medium or user [Bubenko et al., 2010, Moody, 2009, Zarwin et al., 2014].

3.4 Summary

This chapter has provided the basic terminological background relevant to our research. We pointed out to the long-standing debate in studying signs, and languages, which essentially differently considers the role of the context (of purposeful action) for using and understanding signs. The difference in this foundational position implies also a different orientation in studying role and use of languages, and we portrayed several pertinent perspectives on studying natural languages, relevant for the research conducted in the thesis. In addition, we have briefly mentioned the semiotic study of signs in terms of syntax, semantics and pragmatics, and its influence on the linguistic research. Finally, this provides the context for understanding the traditional distinction of syntax and semantics in the research on conceptual modelling languages.

and Rumpe, 2004].

⁷Additionally, the medium itself can be restricted to a specific form, such as graphical, textual, or video, but the notation in general can also be restricted in terms of fonts, icons and layout rules

Part II

Conceptual Framework

CHAPTER 4

A Fundamental View on Modelling

In this chapter, we present our proposition of a fundamental view on modelling, which revisits the existing constructivist notions of models, and offers a critical synthesis of existing contributions. In Section 4.1, the methodological considerations, as well as the grounding of our contribution are presented. Thereafter, the critical analysis of the existing body of knowledge (Section 4.2) motivates the formulation of a fundamental view on models, modelling and role of purpose (exposed in Section 4.4). This forms the terminological and conceptual foundation for other contributions in the thesis.

4.1 Grounding and Method

The view on modelling that we expose in this chapter is developed from the socio-pragmatic constructivist stance, and is grounded in work in cognitive sciences [Johnson, 1987, Lakoff, 1987] and semiotics [Falkenberg et al., 1998, Short, 2007].

This contribution emerged as the result of a *critical synthesis* of the selected related work, namely [Falkenberg et al., 1998, Frank, 2011b, Hoppenbrouwers et al., 2005b, Kaschek, 2013, Mahr, 2009, 2011, Proper et al., 2005, Rothenberg, 1989, Stachowiak, 1972, Thalheim, 2012, 2013, von Braun et al., 1999, Wyssusek et al., 2001a,c]. The contribution is justified relying on both *coherence* and *consensus theory of truth*, as illustrated in the Figure 4.1. Regarding coherence theory of truth, the proposed contribution is coherent with the existing selected related work which adopts the constructivist orientation on modelling. With respect to the consensus theory of truth, this contribution, in different stages of maturity, has been published in [Bjeković et al., 2012, 2013, 2014a, Bjeković and Proper, 2013, Bjeković et al., 2014b].

With respect to the existing body of knowledge, our contribution focuses on the explicit consideration of pragmatic aspects of modelling, in particular the notion of model *purpose*, as construed from the SPC stance (Chapter 2). While *purposefulness* of models is widely considered as the main discriminant of model value [Hoppenbrouwers et al., 2005b, Rothenberg, 1989, Stachowiak, 1972, Thalheim, 2013], the notion of purpose is rarely defined, and its role in the modelling process is scantily discussed. In our work, we define the notion of purpose and characterise its influence in modelling, thereby answering research question **RQ 1**, namely:

RQ 1. *What is the role of purpose in modelling, and specifically, how does it affect the process of model creation?*

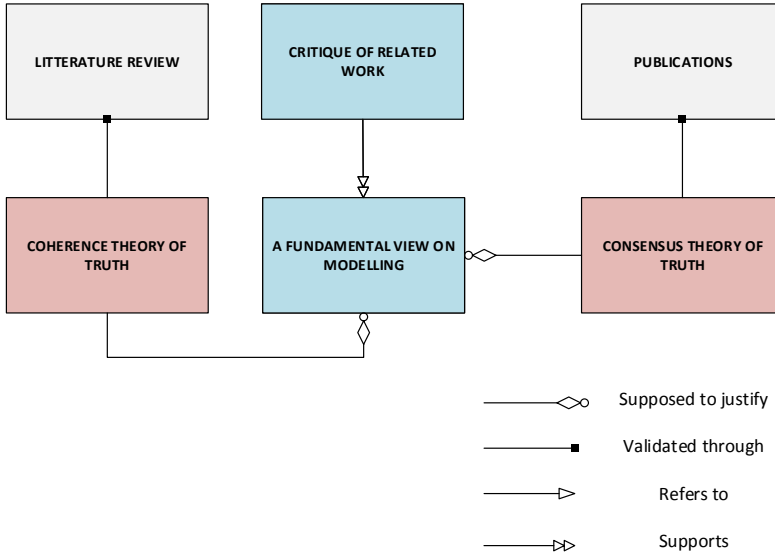


Figure 4.1: A fundamental view on modelling: method aspects of the contribution.

Selected related work is identified and considered through the review of existing literature on the subject, realised as semi-exhaustive review [Cooper, 1988]. We estimated that opting for a systematic literature review on ‘model’, ‘modelling’, and ‘purpose’ in all the potentially relevant areas is not feasible, given the possible overload with a wide range of interpretations of these terms. Additionally, knowing that a constructivist orientation on modelling is not in the mainstream in our research field, the classical systematic literature review was also estimated as less likely to provide relevant results within a

reasonable timespan. Therefore, we opted for a semi-exhaustive literature review, which resembles the snowball sampling strategy. First of all, we took into account the views on modelling and modelling theories which are in line with the constructivist orientation adopted in our research, even if the stance adopted by the relevant authors is not made explicit in their work. Secondly, we initiated literature review with the review of most influential (constructivist) authors within the broader arena of information systems, conceptual and enterprise modelling. Relying on the cross-referencing (snowball sampling), further sources and directions of literature study were identified, and pursued to ensure the relative exhaustiveness of our literature review.

The contributions retained for the in-depth analysis and synthesis satisfied the following criteria: they are available in English, touch on or discuss, in any degree of detail, the notion of purpose and its role with regards to models and modelling. The list of retained authors with the essence of their view on model notion is summarised in Table 4.1.

Author	Scope	Model definition
Stachowiak [1972]	General model notion	<p>Three essential model properties:</p> <ul style="list-style-type: none"> • Mapping property: Models are always models of something. They are representations of certain originals or prototypes, natural or artificial; • Shortening property: Models generally do not map all the attributes of the original, but only those that are relevant for the modeller or model-user. • Pragmatic model-function: models are not in themselves coordinated with the originals. They always fulfil the function of substitution only for subjects with goal-dependent mental or factual operations within certain lapses of time.
Rothenberg [1989]	General model notion	<p>Three essential attributes:</p> <ul style="list-style-type: none"> • Reference: it stands instead of a referent; • Purpose: it has an intended cognitive purpose with respect to its referent; • Cost-effectiveness: it is more cost-effective to use the model than the referent for this purpose. <p>To model is to represent a particular referent cost-effectively for a particular cognitive purpose.</p>

Author	Scope	Model definition
Falkenberg et al. [1998]	Information systems	A model is a purposely abstracted, clear, precise and unambiguous conception. A model denotation is a precise and unambiguous representation of a model, in some appropriate formal or semi-formal language.
Wyssusek et al. [2001c]	General model notion	<p>Inspired by [Stachowiak, 1972].</p> <ul style="list-style-type: none"> • Model is mapping something. This has to be determined by what a community behind the models regards as worthy of representation. • Reductive trait of models: From a SPC view, one has to trace the appropriate horizons of meaning and contexts, to elaborate the preferences of the already internalized customary given interpretation modes of model users, and to make explicit what has to be neglected in the given case. • Purposefulness. “Models do not stay in a one-to-one relation to their originals, rather they have a substitution function for certain subjects that is bound to certain situations in a given temporal space and with regard to given imagined or real operations. Also at this point it is possible to intervene only by means of communicative interaction or participation in a practice, both being forms of the mutual acknowledgement of the horizons of meaning (Sinnhorizonte) of model builders and model users.” [Wyssusek et al., 2001c, p.17]
Hoppenbrouwers et al. [2005b], Proper et al. [2005]	Informations systems, conceptual modelling	Model definition from [Falkenberg et al., 1998]
Frank [2011b]	General model notion	Model <i>in general</i> is a construction that results from purposeful abstraction. Model <i>as an artefact</i> is a representation that results from purposeful and conscious construction.

Author	Scope	Model definition
Mahr [2009, 2011]	General model notion	“Ontologically, a model is <i>something as which</i> something is being conceived of, and concretely, being a model is the content of a judgement in which something is being <i>conceived of as a model</i> .” [Mahr, 2011, p. 301]. Model-object is not a model itself, but only if it is conceived of as a model by a judging subject.
Thalheim [2013]	General model notion	Model is a material or virtual artifact which is called a model within a community of practice, based on a judgement of appropriateness for representation of other artifacts (things in reality, systems, ...) and serving a purpose within this community.
Kaschek [2013]	General model notion, conceptual modelling	Not provided in [Kaschek, 2013].

Table 4.1: Selected related work, scope and model definitions.

In the following section, we discuss the critical analysis of the selected related work, concentrating on the most important concepts and underlying the notion of a model. This sets the ground for formulating our own contribution, which is elaborated in Sections 4.4 and 4.5.

4.2 Related Work: Constructivist Model Notion

According to [Wyssusek et al., 2001a, 2002], the traditional concept of model in information systems is built on positivist¹ grounds. In the thesis, we focus on discussing the model and modelling on constructivist grounds, for the reasons discussed previously in Chapter 2.

The constructivist notion of model construes the latter as more than purely a (reductive) mapping of an objectively existing reality. In the following, we introduce the cornerstones of a constructivist model notion, at the same time critically reviewing some of the differences in views of relevant authors. The discussion is organised in terms of the following topics:

- Notion of world in constructivist model notion (Section 4.2.1),
- Epistemological considerations (Section 4.2.2),
- Consideration of cognitive aspects in different works and their influence on characterising the domain of a model (Section 4.2.3),

¹Positivism is also referred to as naive realism in e.g. [Falkenberg et al., 1998, Frank, 2006] or objectivism in e.g. [Falkenberg et al., 1998].

- Different perspectives on the nature of a model (Section 4.2.4),
- Role of purpose in modelling (Section 4.2.5), and
- Consideration of model-being and human judgement (Section 4.2.6).

4.2.1 Ontological Basis: World as Construction

As a paradigm of inquiry, *positivism* assumes the objective existence of reality independently of human mind (ontological position). On positivist grounds, humans are able to access entities and properties of reality directly, i.e. without any cognitive bias (epistemological position): “Knowledge exists if “real” objects with their innate properties and relations are represented (mapped) in the human mind with the same properties and relations” [Wyssusek et al., 2001a, p. 190].

In contrast to this stance, *constructivism* is rather indifferent with regards to the objective existence of the reality. While not denying the existence of the world outside of the human mind, constructivism assumes that human notion of reality is rather a *construction*. This notion allows to cover anything that humans can conceive of, whether it has actual existence in ‘reality’ or not [Frank, 2011b, Mahr, 2012, Rothenberg, 1989]. While Frank [2006, 2011b, 2017] uses the notion of *possible worlds* to refer to this, [Karbe, 2011, Mahr, 2011] allows for a broader characterisation through the claim that human conceptions can have as their content anything that is of interest for human mind [Karbe, 2011, Mahr, 2011]. This goes beyond the ‘real’ and ‘possible’ worlds dichotomy, and allows to encompass all human experiences, regardless of when they occur – present, past or future – and regardless of their ‘modalities’, i.e. whether they have as their content physically manifested or non-manifested phenomena². In essence, one could say that constructivist notion of world covers ‘world as experienced by the observer’, whereby the content of that experience – at least from the SPC stance – is (considered as) to some extent influenced and governed by social consensus.

4.2.2 Epistemological Differences

Indeed, amongst constructivist authors, one can find differences with regard to the epistemological assumptions adopted, or to how explicitly they are adopted in the considered work. We will hereby rely on the distinction of two main epistemological variants of constructivism, as proposed in the work of [Wyssusek et al., 2001a,b, 2002]. Concretely, *radical constructivism* adopts subjectivist epistemology, and explains the reality construction only based on the cognitive processes of an individual. On the other hand, *socio-pragmatic constructivism* states that human access to the world and knowledge is only possible through taking part in social and cultural practices within the community. Therefore, socio-pragmatic constructivism emphasises that human cognition is

²For instance, the example of unicorns and other imaginary creatures [Lyytinen, 2006], as element of human construction and knowledge of the world, stands for non-manifested phenomena.

influenced *both* by individual *and* cultural-historical experiences of the community in which an individual is situated. In that sense, Wyssusek claims that world is “not constructed by a single individual. It is rather embedded in a social context with social practices that eventually determine individual actions” [Wyssusek et al., 2002, p. 834].

Author	Epistemology	Paradigm of inquiry
Stachowiak [1972]	Does not exclude subjectivist interpretation	Constructivist
Rothenberg [1989]	Implicit	Implicitly constructivist
Falkenberg et al. [1998]	Implicit subjectivist	Does not exclude radical constructivist, although not intended as such [von Braun et al., 1999]
Wyssusek et al. [2001c]	Explained based on human cultural history [Wyssusek et al., 2002]	SPC
Hoppenbrouwers et al. [2005b], Proper et al. [2005]	As Falkenberg et al. [1998]	As Falkenberg et al. [1998]
Frank [2011b]	Implicitly SPC	Constructivist
Mahr [2009, 2011]	Implicitly SPC, allows for subjectivism	Does not exclude radical constructivist stance
Thalheim [2013]	Constructivist	Constructivist
Kaschek [2013]	Implicitly SPC	Constructivist

Table 4.2: Selected related work, ontological and epistemological positions

The epistemological positions across the studied literature are summarised in Table 4.2. Although not explicitly stated, the views on model notion by [Frank, 2011b, Kaschek, 2013, Thalheim, 2012, 2013] can be considered as in line with the epistemology of SPC stance (Section 2.1).

The view on models proposed by [Mahr, 2009, 2010a,b, 2012] is developed from a constructivist position. In this work, the nature of models is explained in terms of the wider context of intentionality, and as the content of judgement of model-being [Mahr, 2009] by a conceiving subject. In this context, the conceiving subject may include an individual, group, scientific community, nation, etc³, but does not go into further discussion of epistemological assumptions, hence implicitly allows for both interpretations (radical constructivist and SPC). Nonetheless, the fact that these aspects are not explicitly discussed in Mahr’s

³Examples for possible conceiving subjects within the frame of Mahr’s model of conception, given in [Karbe, 2011, Mahr, 2011], include an individual, scientific community, a whole nation, a cultural period, even a mathematical definition. Nonetheless, Mahr explicitly states the constraint that the for models and judgement of model-being, a conceiving subject has to be human [Mahr, 2011].

work is, in our view, a matter of his focus towards characterising *structural and constitutive* relationships underlying model-being, and consequently, implicitly backgrounding the question of the nature of conceptions' content. Furthermore, Mahr aims to characterise this web of relationships in general cases [Karbe, 2011, Mahr, 2012], and not specifically reducing it to the human beings only, therefore the influence of language and social practices are not necessarily in his primary focus.

In the field of information systems, the FRISCO report [Falkenberg et al., 1998] is well-known as one of the first proposals adopting the constructivist orientation on models and modelling. [Falkenberg et al., 1998] defines the notion of model as “a purposely abstracted, clear, precise and unambiguous conception” [Falkenberg et al., 1998, pg. 55]. In turn, *conception* is defined as “resulting from an action whereby a human actor aims at interpreting a perception in his mind, possibly in a specific action context” [Falkenberg et al., 1998, p. 47]. Although the report otherwise insists on inter-subjectivity of human knowledge, the above definitions leave the space for a radical constructivist interpretation. Indeed, FRISCO report was criticised by [von Braun et al., 1999], for the fact that conceptions were approached from “a pure mentalistic point of view or introduced via terms of perception psychology” [von Braun et al., 1999, pg. 1]. The critical refinement proposed in [von Braun et al., 1999] forwards that conceptions are inherently “social constructs, formed by a language community through common use and shared understanding. Thus they are a product of *social agreement* and may vary if such agreements change in time.” [von Braun et al., 1999, pg. 9]. This can indeed be regarded as FRISCO's refinement towards SPC epistemology⁴. This epistemological position is also the one maintained in our discussion of models, modelling and use of language.

4.2.3 Human Cognition and Modelling

The essence of constructivist relativist ontology lies in the appreciation that human cognition goes beyond just mirroring the physically manifested reality. Generally speaking, constructivist view on models and modelling should be more attentive to the influences of human cognitive processes.

Context and Intentionality

The fact that human cognition is inevitably bound to context and intentionality is not new. What this implies is that human access to the world, bound to context and intentionality, is inherently and inevitably partial, i.e. **perspectival** or **aspectual**. The fact that we can never have access to the world in its entirety should be taken as the starting point not only for understanding human cognition and conceptual knowledge⁵, but also models and modelling.

⁴Note, however, that SPC as a paradigm of inquiry was only developed several years following the FRISCO report publication.

⁵Within cognitive linguistics [Geeraerts, 2010], the fact that context and intentionality are permeating our making sense of these experiences is also seen as a having a major influence

In the literature on modelling, the influence of context on conceptualisation [Hoppenbrouwers and Wilmont, 2010, Mahr, 2011] and on model shaping [Stachowiak, 1972, Thalheim, 2013] is acknowledged. However, this influence is not much detailed, and the implications of context-dependency and of aspectual character of cognition on some central modelling notions (e.g. abstraction, conceptualisation, concepts) are rarely discussed in depth and elaborated on.

In [Falkenberg et al., 1998], conceptions are characterised as taking place in a conceiving context [Falkenberg et al., 1998, pg. 47], but this influence is not further discussed. Stachowiak [1972] goes into more details of the subject- and intention-dependency in his characterisation of pragmatic model-function, claiming that it needs to be clear for which subjects and goals models stand in substitution function. A rare elaborate discussion of the influence of subject-, context-, and intention-dependency of all human cognitive processing can be found in [Mahr, 2012]. Mahr’s model of conception [Karbe, 2011, Mahr, 2012] characterises the most fundamental notions of context, object of conception, subject of conception, entity, relationship etc. According to Mahr, “since an object conceived of is conceived of in certain circumstances, including the objects presence, its origins, its conditions of being there, its effects on other objects, the background of knowledge in front of which it is conceived of, the perspective taken on it and many more things, all of which depending in one or the other way on the subject conceiving of it and on the situation in which it is being conceived of, the object has its content in a certain *context* of being, context being a complex of relationships” [Mahr, 2012, p. 345].

Entity–Property–Relationship Structures

In addition, the organisation of cognitive processes and human conceptualisations in terms of entity–property–relationship structures is recognised by Mahr [2009, 2011] and Stachowiak [1972] as another source of human cognitive bias⁶. While, on the positivist grounds, entities and properties are considered as having objective existence in reality, [Mahr, 2009, 2011] and [Stachowiak, 1972] explicitly discuss that human mind ‘imposes’ these structures when conceiving certain aspects of the world under consideration, and that as such entities do not have objective existence. More precisely, Stachowiak [1972] claims that “the distinction between individuals and attributes is not based upon any ‘metaphysics of substance’. According to suitability, any object-constituting elements can, in one context, stand for attributes, in another, for individuals [...] No attribute (proper and improper) can be said to belong to an object as such. All its attributes are ‘attributed’ to the object [...] Attributes are primarily products of perception and cogitation” [Stachowiak, 1972, p. 145-146]. Similarly, Mahr claims that “an *entity* is not prescribed by the model as to

on the objectification of different domains of human experience within language.

⁶In the research on categorisation, Johnson [1987], Lakoff [1987], Lakoff and Johnson [1980] show that human mind imposes entity-relationship-like structures (known as image schemas [Johnson, 1987]) when making sense of experiences [Geeraerts, 2010, Lakoff, 1987]. These, deeply rooted and unconscious principles are the most fundamental devices of cognitive organisation, and also underly the structuring of human conceptual knowledge and language. In the thesis, this topic is the subject of our discussion in more details in Chapter 6.

being a thing as such, but is intended to be something which exists through the fact that it is being conceived of by some subject” [Mahr, 2012, p. 345]. This, obviously, stands in contrast with the entities in ontologies, which are supposed to be objective, in the sense of being independent of human mind. In Mahr’s model of conception, entities (as content of the conception) are both context- and subject-dependent. “Consequently, the model itself and each ontology are entities and as such subject-dependent” [Karbe, 2011, p. 100].

Therefore, while entities and properties are universal structures in terms of which humans organise cognitive processes and conceptual knowledge (as also forwarded in Chen’s early proposal of the ER model [Chen, 1976]), the particular organisation of entities and properties is related to and dependent on a specific cognitive perspective, intentions and background assumptions of the conceiving context.

The Notion of Domain

The aspectual character of human cognition basically means that our access to the world is always limited to the certain domains of experience. The implications of this position to characterising the notion of domain are not necessarily always clearly forwarded.

Table 4.3 presents an overview of the terms used in the literature to refer to the similar concept, such as e.g. *referent* [Rothenberg, 1989], *origins* [Thalheim, 2013], *original* [Stachowiak, 1972], or *domain* [Falkenberg et al., 1998, Hoppenbrouwers et al., 2005b, Proper et al., 2005]. Our choice of the term **domain** is related to the fact that the latter is less likely to trigger connotations of positivist ‘flavour’⁷.

Additionally, we consider it necessary to make a clear distinction between the notions like **domain of discourse**, **domain of interest** and **domain of experience** and a specific notion of domain. While the former three notions all characterise (the knowledge of) an area or subject matter on a high-level of consideration, i.e. independent from different contexts, we consider the notion of domain to be more specific. Namely, it relates to the domain identified in a concrete modelling context and its particular goals, and is context-dependent notion. Roughly speaking, we could say that the domain is a ‘concretisation’ of some domain of interest within a given modelling context.

In line with the constructivist ontology, the notion of domain is recognised by most authors as going beyond covering just the directly observable elements of ‘reality’. Furthermore, Falkenberg et al. [1998], Frank [2011b], Mahr [2011] also underline that the delimitation of domain cannot be a priori known, as it is due to the context and goals of modelling. The definition given by Falkenberg et al. [1998] (Table 4.3) characterises domain as referring to ‘parts’ or ‘aspects’ of the world considered, which are relevant for the given context and goals of

⁷For instance, potentially also due to the historical background, the use of notion of original, origins and referent of a model bears a slight positivist connotation. The burden of this connotation surfaces, for instance, in Rothenberg’s characterisation of a model referent in [Rothenberg, 1989], where he has to underline that: 1) the referent need not have its actual existence in the reality, and 2) that model-referent relationship is not necessarily based on a reductive abstraction.

modelling. It is noteworthy that this characterisation should not be interpreted in a positivist way, namely that the world considered has some kind of stable organisation in terms of ‘parts’ or ‘aspects’, which are singled out (reductive abstraction feature) in some context. This oversimplification is, however, often implicitly assumed in different works.

We consider critical to emphasise the nuance in the understanding of domain we propose. According to constructivist notion of world, and general perspectival nature of human cognition (previously discussed in the present section)⁸, the notion of domain within a given modelling context is characterised by the *perspective* adopted on the domain of interest [Karbe, 2011, Mahr, 2011, Stachowiak, 1972]. The adopted perspective also entails a particular delimitation and structuring of domain in terms of entities, properties and relationships. This understanding is present in the discussions by [Karbe, 2011, Mahr, 2011, Stachowiak, 1972], and will be the basis of the notion of domain used in our thesis. However, in contrast to the referred authors, we explicitly introduce the notion of perspective and cognitive structuring in domain characterisation.

The notion of perspective is inspired by Karbe [2011], Mahr [2011], Stachowiak [1972], while also congruent with the notions of *construal* and *perspectivisation* within cognitive sciences [Lakoff, 1987, Verhagen, 2010].

While the notion of perspective might be more intuitively understood, the idea of ‘imposed’ cognitive structuring of the domain (based on the adopted perspective) may appear less obvious. This in particular is the case when we consider the domains pertaining to ‘objects’ that have a clearly distinguishable manifestation in the physical space, such as e.g. chair, house, tree, transport infrastructure. Nonetheless, in the case of abstract domains of experience, such as e.g. emotion, organisation, strategy, etc., it is easier to grasp the idea that human mind imposes cognitive/conceptual structuring on our experiences. This topic will be further discussed and illustrated in Chapter 5, and is of particular importance for the study of the role of conceptual modelling languages.

4.2.4 The Nature of Models

Understood on positivist grounds, the nature of model is subsumed to simply establishing a *mapping* (or representation) of a ‘true’ reality. The essence of model here lies in an *abstraction*, i.e. an intentional neglect of the irrelevant entities and properties of true reality (i.e. reductive mapping). However, based on the constructivist grounds, the representational model notion is transcended: “Models are no longer considered to be an objective representation of reality, but are subject to the context-dependent interpretation of the individual – with the context provided by his/her social environment” [Wyssusek et al., 2001a,

⁸This perspectival nature of human cognition is inherently linked to Heidegger’s notion of *breaking down*, as discussed throughout [Winograd and Flores, 1986]: “Heidegger insists that it is meaningless to talk about the existence of objects and their properties in the absence of conference activity, with its potential for breaking down. What really *is* is not defined by an objective omniscient observer, nor is it defined by an individual – the writer or computer designer – but rather by a space of potential for human concern and action” [Winograd and Flores, 1986, p.37].

p. 191]. Consequently, the model-world relationship is considered with more nuance within the constructivist model notion.

Author	Domain	Mental model is a model?	Model artefact as
Stachowiak [1972]	Models are representations of certain originals, or prototypes. Originals can be natural or artificial, and even originals can be models also.	No	Yes, representation.
Rothenberg [1989]	Model is of something, it has the referent. The referent of the model need not actually exist, but must be objectively testable in order to serve as the 'reality' for the model. Model is not necessarily simpler than its referent, it may well be more complex.	No	Yes
Falkenberg et al. [1998] Hoppenbrouwers et al. [2005b] [Proper et al., 2005]	"A domain comprises any "part" or "aspect" of the "world" under consideration [..] Neither a domain, nor any of its components, nor its environment can be determined a priori. They can be determined only a posteriori, after perceiving and conceiving that domain" [Falkenberg et al., 1998, p. 46].	Yes	Model denotation
Wyssusek et al. [2001c]	Original, domains.	No	Yes

Author	Domain	Mental model is a model?	Model as artefact
Frank [2011b]	“A domain is a subject area or field of interest. It is not restricted to existing objects or phenomena, but may also include potential objects and phenomena. A domain can be characterised by the objects it includes, features of these objects, or functions provided by the objects. Objects include physical objects, human actors, and immaterial objects” [Frank, 2011b, p. 2].	Model in general	Yes, model as construction
Mahr [2009, 2011]	Introduced through the notions of cargo, source object and mental model in the web of relationships in the epistemic pattern of model-being see [Mahr, 2011, p.286].	Mental model is part of the epistemic pattern of model-being only.	Model object represents the mental model.
Thalheim [2013]	Origins	No	Yes
Kaschek [2013]	–	No	Yes

Table 4.3: Selected related work, features of models

Beyond Abstraction and Reductive Mapping

The previously discussed understanding of the notion of domain has implications for the characterisation of relationship between *model* and *world*. Instead of claiming the essence of models to be in the *reductive mapping*, constructivist notion of model rather places conceptions at heart of modelling (This may appear less obvious in the model notions of Stachowiak [1972] and [Rothenberg, 1989]).

Traditionally, the process of delimiting the domain is referred to as the mechanism of *abstraction*, and is considered as lying at the heart of modelling. However, as previously already discussed, the world is not objectively given and pre-structured, but also modelling can cover past, present, future and ‘possible worlds’. In addition, there is the creative aspect in conceiving the domain, resulting from adopting a particular perspective and ‘applying’ a particular

structuring of the domain. Therefore, the identification of the domain cannot be reduced to only application of *abstraction* mechanism, but is a creative act which results from using the entirety of human cognitive abilities, not only from applying abstraction. In this context, if we understand abstraction as an essential and pervasive mechanism of human cognition whose essence consists in placing a point of focus [Hoppenbrouwers and Wilmont, 2010, Wilmont et al., 2010] on a subject matter, we can say that the notion of abstraction and perspective can nearly be equated.

If model can refer to both existing, past and ‘possible’ worlds, then model does not stand in reductive relationship to the ‘world’. It indeed can exhibit different *transformation* qualities with regards to ‘reality’, as is exemplified via different potential properties of models, discussed by Thalheim [2011, 2013]: *truncation property*, *extension property*, *distortion property*, *amplification property*, *idealisation property*, etc. Even more, the model-world relationship may entail simultaneously both reductive and transformative qualities.

Therefore, model-world relationship is not a straightforward one, and the notions of *abstraction* and *reductive mapping* are not appropriate to capture the essence of this relationship. Rather, faithfully representing what is directly observable in the physically manifested world is only a special case of the more general notion of modelling. Stachowiak discusses the model having a substitution function with respect to the original (i.e. domain) bypassing the direct model-world relationship. Furthermore, substitution function is not absolute, it holds “only for subjects with goal-dependent mental or factual operation within certain lapses of time” [Stachowiak, 1972, p. 150].

[Frank, 2011b] points at the same problem of using *abstraction* and *mapping* to characterise the nature of models. In response to these problems, Frank posits the definition of model (as an artefact) as “a representation that results from a purposeful and conscious construction. It is perceivable and can be communicated. The abstractions it is based on depend on the purpose of the construction, mental activities of those involved in the construction and additional external stimuli and constraints” [Frank, 2011b, p. 4]. The construction in the above definition is used to underline the same qualities of conceptions that we previously discussed. Similar to our position, Frank also states that construction is in part the result of an abstraction, but considers abstraction also as a construction (in the sense of creating something new [Frank, 2011b]). In our view, however, this circularity between the notions of abstraction and construction is not necessary.

Beyond Conception vs. Artefact Dilemma

While models are based on conceptions, this is not sufficient to characterise something in its role as a model. In line with [Kaschek, 2013, Mahr, 2009, 2011, Rothenberg, 1989, Stachowiak, 1972, Thalheim, 2013], we consider that the artefact dimension is equally crucial for characterising the nature of models.

Nonetheless, Falkenberg et al. [1998] defines model as “a purposely abstracted, precise and unambiguous conception”. Therefore, in FRISCO, the notion of model allows it to be just the conception, and to have no physical

manifestation. The problem with this view is that, as the conceptions reside in mental space, they cannot be anyhow evaluated for satisfying any of the above-mentioned qualities (i.e. purposely abstracted, unambiguous and precise). As a consequence, any conception is a model and none of them is. Therefore, it is only when the conception is externalised in the physical space, that the evaluation of mentioned qualities becomes possible. This indeed is implicitly acknowledged in the FRISCO's definition of the *model denotation* as "precise and unambiguous representation of a model". Evidently, both precision and unambiguity are repeated in the latter definition. In our view, this is a consequence of the claiming conceptions to be models in the first place.

Kaschek [2013] underlines that a strong focus on adopting the abstraction as defining characteristics of models fails to acknowledge the fact that models are chiefly representations. In that sense, "it is thus not suitable to regard a model as a mere abstraction. One should rather regard it as an abstraction injected into some "material" that, by its fundamental properties and particular instantiation, enables to make the intended use of the information as inherent in that abstraction and as required by the model's purpose. Models are chiefly representations and successful models are handy representations." [Kaschek, 2013, p. 92]. This point is nicely illustrated in his example of the city map as a model: "Consider a conventional pocket-city-map of Torshavn, the capital of the Faroe Islands. Then most likely everyone agrees that it can be considered as a model of Torshavn. And of course it also represents an abstraction of Torshavn as many of that city's characteristics are not reflected in that map. It does, for example, not tell how the wind feels when you walk the harbor in winter; how folks look like who walk the streets; how the music sounds in the pub during a jazz-concert and many things more. Obviously for the purpose of navigating through the city, in most cases, the ignored information is irrelevant. It would, nevertheless, be false to simply consider that map as a mere abstraction of that city. In fact important usage characteristics of that map result from characteristics it does not inherit from its original: It has a legend, complies with map-related conventions, can be folded, be put into one's pocket and you can have it on you when you walk the streets in order to get to some particular location. None of these characteristics is a characteristic of the city Torshavn." [Kaschek, 2013, p.91].

Mahr [2011] also distinguishes between mental model and model as artefact, whereby both participate in the epistemic pattern of model-being [Mahr, 2011, p.286], and contribute to what makes something a model. According to [Mahr, 2011], the model-being of that object is dependent on the judgement and context in which that object is placed. The elements of this judgement and the role of mental model and representation/artefact in it are discussed in depth in Mahr's epistemic pattern of model-being [Mahr, 2011, p.286], based on two relationships of creation. In essence, model object (artefact as model) is created within a certain application in mind, and with the intention to carry some qualities of source object (i.e. domain) for that application. For more details, see [Mahr, 2011].

4.2.5 The Notion and Role of Purpose

Purposefulness is widely acknowledged as one of the most important dimensions of models. Nonetheless, the notion of purpose is rarely defined, and its influence in modelling is rarely discussed in detail. Most authors put forward the fact that purpose influences the abstraction, i.e. conceiving process, in the sense of model resulting from *purposeful abstraction* [Falkenberg et al., 1998, Rothenberg, 1989] or *purposeful construction* [Frank, 2011b].

For Thalheim [2012, 2013], purpose relates intentions and the means for their realisation. Additionally, purpose governs the model, its development and its application process. Consequently, the use of model outside of its purpose should not be allowed [Thalheim, 2012, 2013].

Frank [2011b] acknowledges that the shaping of model as artefact depends on the purpose, mental activities of those involved in the modelling process, and external constraints and influences. In this context, purposefulness of the model stresses the fact that creation and introduction of the model as such, as well as the choice of abstraction used, needs to be a conscious and intentional act.

Apart from these observations, the only authors that, to our knowledge, attempt to clarify and go into more details in understanding purpose and its influence on different activities of modelling, are [Mahr, 2011, Rothenberg, 1989, Stachowiak, 1972].

Stachowiak [1972] discusses the influence of model purpose on the shaping of model in relation to his *shortening property* and *pragmatic property*. According to Stachowiak, the pragmatic dimension of models in a wider sense points to the fact that models only map those attributes to the original relevant for modeller or model-user, while “*in a narrower sense, the selection of attributes becomes pragmatic only when it follows definite operational aims, and, moreover, when it is clear at what times the model does represent the original, and, above all, for whom*” [Stachowiak, 1972, p.150].

Rothenberg [1989] sees the *purpose* as one of the essential attributes of models. He understands the notion of purpose in the sense of being a cognitive purpose with respect to model’s referent. He is, to the best of our knowledge, perhaps the only author to explicitly introduce the notion of trade-off in modelling through the criteria of *cost-effectiveness for the purpose*. The essence of *cost-effectiveness for the purpose criteria* consists in the trade-off between costs of creating the model and expected benefits of using it: “It must also be cost-effective to use the model for the given purpose than to use its referent, either because it is impossible to use the referent directly or because using the referent would be dangerous, inconvenient, or (generally) expensive in some relevant coin” [Rothenberg, 1989, p. 78]. Cost-effectiveness for the purpose is understood by Rothenberg as central to modelling, and is referred to as an “Occam’s razor for modelling” [Rothenberg, 1989, p. 78], as it allows for the two models of equal power to be compared and evaluated.

Furthermore, for Rothenberg, purpose and cost-effectiveness for the purpose as criteria provide the complete *functional characterisation of models*. They influence the abstraction process, e.g. by determining the complexity of model and the degree of its faithfulness to the referent (here using Rothenberg’s

terminology). These criteria must also be known in order to judge the model's value. Furthermore, these criteria determine a number of (what Rothenberg refers to as) *pragmatic characteristics of models*, such as usefulness and usability by its intended users, as well as eventual required maintenance of the model.

4.2.6 Judgement of Model-Being

The notions of model advanced by [Frank, 2011b, Mahr, 2009, 2012, Thalheim, 2013, Wyssusek et al., 2001c, 2002] all underline the importance of human explicit judgement for the establishment of model-being [Mahr, 2009] of an artefact/representation.

For [Stachowiak, 1972], models only play their pragmatic model-function for certain model-users and within certain constraints. Frank [2011b] posits the importance of both conscious and deliberate human judgement which introduces a particular representation as model. In turn, Rothenberg [1989] speaks about the trade-offs underlying this judgement explicitly, introducing the notion of *cost-effectiveness for purpose*. For Rothenberg [1989], a model is a special kind of representation, specific in that the model justifies the criteria of purpose and cost-effectiveness of purpose. These two latter criteria are thus crucial for establishing model-being. This implies the necessity of a conscious and deliberate human judgement.

This judgement, generally speaking made by the group of people acting as model creators, needs to take into account the intended users and uses of the model. Therefore, the model users or model audience need to be accounted for, especially when these latter are not simultaneously acting as modellers/model creators.

4.3 Reflection

The presented review of relevant theoretical contributions on modelling targeted the answering of the **RQ 1**, i.e. it aimed to clarify the notion of purpose, and its influence in conceptualisation and model creation.

While most constructivist-oriented authors appreciate the context and intentionality as important elements in modelling (Section 4.2.3), the implications of these elements on the delimitation and structuring of a *domain* within a modelling context are not, in our view, considered in sufficient detail. Therefore, we deem crucial to provide a more precise characterisation of the notion of domain. Our discussion in Section 4.2.3 demonstrates that cognitive processes lie at the heart of domain delimitation and structuring, and that the notion of domain is inherently related to the (cognitive) perspective taken on the subject matter.

Furthermore, in the review of existing related literature, we conclude that the reviewed contributions do not in detail scrutinise the role and influence of purpose on shaping the model in modelling process. When purpose is unanimously considered as a key element in modelling, little attention is paid to how purpose influences decisions taken in shaping both domain and model. To the best of our knowledge, this aspect is only explicitly introduced

in [Rothenberg, 1989], through the notion of cost-benefit ratio for the purpose (Section 4.2.5).

Within the context of our research, the above-mentioned clarifications regarding the notions domain and purpose are crucial, as they set conceptual and terminological basis for discussing the influence of concepts and of modelling language in conceptual/enterprise modelling process. We, however, could not integrate the required refinements within any already existing theoretical proposition, without modifying its adopted assumptions and terminology. We thus opted to integrate the proposed refinements into a coherent conceptual and terminological framework, which while based on the critical synthesis of the reviewed contributions, also clearly adopts SPC stance. Our proposition of a fundamental view on models and modelling is presented in the following sections, namely Section 4.4 and 4.5.

4.4 Model Definition

We introduce the notion of model used in this thesis [Bjeković et al., 2014a], which brings together different elements of proposals developed by [Frank, 2011b, Mahr, 2009, 2012, Rothenberg, 1989, Thalheim, 2013], while adding refinements as discussed in Section 4.3.

We define the notion of model as follows:

*A **model** is an **artefact** acknowledged by the **observer** as representing some **domain** for a particular **purpose**.*

4.4.1 Conception, Artefact, Model

By stating that a model is an **artefact**, we exclude *conceptions*, or so-called mental models, from the scope of this definition.

Conceptions are here understood in terms of [Mahr, 2012]’s characterisation, as mental states having a certain propositional content regarding the “*world*” *under consideration*, and adopted from a certain perspective.

It is important to note that a conception resides in the mind of an observer holding it, and as such it is not directly accessible (via the senses of perception) to a fellow human being. For this to happen, a conception needs to be *externalised* in physical space, either material or virtual [Thalheim, 2013]. This is achieved by means of artefacts. By doing so, the observer attributes to the created artefact function of representation of the domain for particular purpose.

Like a representation, being a **model** is also a *function* of an artefact. It is a special case of the representation function [Rothenberg, 1989]: the **model function** is attributed to the artefact only by the virtue of the observer’s *judgement* that it represents domain in a way which makes this artefact fit for purpose.

Putting forward the artefact, i.e. *representation dimension* as essential for model characterisation marks a clear difference from the views of [Falkenberg et al., 1998, Hoppenbrouwers et al., 2005b], and is more in line with [Frank, 2011b, Kaschek, 2013, Mahr, 2009, 2012, Rothenberg, 1989, Thalheim, 2013].

Having said that, we do consider that conceptions play a fundamental role in modelling, which is elaborated in Section 4.5.

4.4.2 Domain

In line with the discussions in Section 4.2.3, we understand the **domain** inherently tied to the *perspective* adopted by observer in considering relevant world. This perspective entails the delimitation in terms of ‘parts’ or ‘aspects’ of the *world considered relevant by the observer* in a given *modelling context*, and implies a particular cognitive/conceptual structuring of domain in terms of entities, properties and relationships.

This implies even the same domain of interest, when considered from a different perspective, by the very same observer, can result in different delimitation in terms of relevant ‘aspects’, and also potentially different cognitive structuring being ‘imposed’. In this case, we speak of differently shaped *domains* within two different modelling contexts, both pertaining to virtually the same domain of interest (See Section 4.2.3).

Note that the constructivist notion of domain allows to cater for both actual, past, future and possible worlds in modelling. Even more, the domain of a model can be another artefact [Thalheim, 2013], or another model [Stachowiak, 1972].

4.4.3 Observer and Model-Being Judgement

The **observer** as used in our model definition refers to the group of people, consisting of model creators and model audience, and engaged in judgement of model-being [Mahr, 2009]. On one extreme, observer can refer to the entire society, and, on the other extreme, to the individual [Mahr, 2011, von Braun et al., 1999, Wyssusek et al., 2001b]⁹.

In line with [Frank, 2011b, Mahr, 2009], we argue that the observer’s explicit judgement is essential for an artefact to act as a model. Without such judgement, an artefact acts still only as a representation, which, at some point in time, may or may not be fit for the given purpose.

As there can be varying levels of judgement of model-being – which is especially relevant in the context of collaborative modelling – we opt for using a more general, and at the same, neutral term of *acknowledgement* of model-being in our definition.

4.4.4 Purpose

In our work, the notion of **purpose** is seen as combining the following interrelated dimensions:

- (1) the **domain** that the model pertains to, and
- (2) the intended **usage** of the model by its intended **audience**.

⁹It is noteworthy that, even in the case of the individual observer, its reasoning is not isolated from the social context and practices of the relevant communities, as entertained by SPC.

In other words, the reason why an observer creates a model in the first place is to enable some *usage* of that model (e.g. analysis, execution, contracting etc.) by its intended *audience* (e.g. business analysts, business decision-makers, enterprise architects, process experts, etc.). The *use* dimension is a key dimension here, as in it lies the utility of the model.

As already discussed in Section 4.2, it is evident that the purpose for which the model is to be used defines the requirements regarding *not only* scope and content of a relevant domain (i.e. cargo [Mahr, 2009, 2011] to be conveyed by the model), *but also* the representation of the model for its intended use and audience [Kaschek, 2013, Rothenberg, 1989]¹⁰.

4.4.5 Illustration

```
Job TEST110
Workstation (Job) TWSAGENT
Job Stream JOBS
Workstation (Job Stream) TWSAGENT

</jstl:orderExecutionOfTasks>
</jstl:resources>
</jstl:jobDefinition>
= TWSRCHAP :
= AGENT : TWSAGENT
= Job Number: 908074632
= Mon Feb 13 08:44:01 EST 2012
=====

Workflow Name: wf_double_task
Runid: 301
Status: SUCCEEDED
Start Time: 13/3/2012 8:44:2
Completion Time: 13/3/2012 8:44:47
Log File Path: C:\Informatica\PowerCenter8.6.1\server\infra_shared\WorkflowLogs\wf_double_task.log

Task Name      Start Time      Completion Time  Status
-----
s_myapp2       13/3/2012 8:44:2 13/3/2012 8:44:8 SUCCEEDED
s_myapp3       13/3/2012 8:44:41 13/3/2012 8:44:45 SUCCEEDED
-----

INFO : Mon Feb 13 08:44:02 2012 [LM_36435] : 5124 Starting execution of workflow [wf_double_task] in folder
INFO : Mon Feb 13 08:44:02 2012 [LM_44206] : 5124 Workflow wf_double_task started with run id [301], run in:
INFO : Mon Feb 13 08:44:02 2012 [LM_44195] : 5124 Workflow [wf_double_task] service level [SLPriority:5,SLD:
INFO : Mon Feb 13 08:44:02 2012 [VAR_27085] : 5124 Parameter file [C:\Informatica\PowerCenter8.6.1\server\i
INFO : Mon Feb 13 08:44:02 2012 [LM_44253] : 5124 Workflow started. Clients will be notified
INFO : Mon Feb 13 08:44:02 2012 [LM_36330] : 5124 Start task instance [Start]: Execution started.
INFO : Mon Feb 13 08:44:02 2012 [LM_36318] : 5124 Start task instance [Start]: Execution succeeded.
INFO : Mon Feb 13 08:44:02 2012 [LM_36505] : 5124 Link [Start -> s_myapp2]: empty expression string, evalu
INFO : Mon Feb 13 08:44:02 2012 [LM_36388] : 5124 Session task instance [s_myapp2] is waiting to be started
INFO : Mon Feb 13 08:44:02 2012 [LM_36682] : 5124 Session task instance [s_myapp2]: started a process with
```

Figure 4.2: A typical process log

To illustrate our proposition, let us take the example of a business process log¹¹, namely an artefact created by process execution software, as illustrated in Figure ???. Is that a model? Without knowing the exact modelling context and purpose, thus also observer and domain, we cannot a priori discuss the model-being of this artefact.

¹⁰Therefore, there is a clear connection between the notions of *model purpose* and *model quality* [Bjeković et al., 2012]. Depending on a given purpose, different qualities of the model are emphasized.

¹¹https://www.ibm.com/support/knowledgecenter/SSGSPN_9.3.0/com.ibm.tivoli.itws.doc_9.3/distr/src_infopc/awsinfopcjoblog.gif

However, if we hypothesise the modelling context where the purpose is business process re-design by business designer, this artefact would likely not stand as a model. The artefact as such does not offer (with certainty) all the relevant information on business activity ordering, corresponding business rules and/or organisational roles responsible for the activities, and therefore would not represent business process adequately for the given purpose.

In another context, the same artefact may stand as a model. For instance, if we speak about business process execution, the process log may well stand as a model of business process (as executed by the specific work-flow engine) to the work-flow specialist with a specific technological knowledge. In this case, the model-being of a process log for e.g. verification of process execution is rooted in the concrete observer's judgement of artefact's adequacy.

4.5 Modelling Process and Role of Purpose

For our consideration of the role of purpose in shaping the model within the modelling process, we first characterise the notions used in the following discussion.

4.5.1 Terminological Considerations

In our discussions, we differentiate between the notions of *modelling effort*, *modelling context* and a *modelling process*.

We characterise **modelling effort** *at least* by the involved observer, the goals of modelling, relevant modelling context, and set of activities leading to a creation of the purposeful model. Note that the **goals of modelling** within the given modelling effort are not necessarily restricted to the goal of producing the model. Particularly, in enterprise modelling, these goals may also refer to organisational learning, achieving consensus on a topic and reaching some commonly agreed knowledge [Bommel et al., 2008, Krogstie et al., 2006]. In our immediate discussion, however, we focus on the goals of producing the desired model-as-artefact, i.e. on model purpose.

Therefore, we refer to the modelling effort using the following symbol: $\langle mc, O, p \rangle$, whereby:

- Modelling context **mc** is given by the wider context to which the modelling effort pertains,
- Observer **O**, i.e. the participants of involved as either model creators or intended audience of the model,
- Purpose **p** of the model.

Our understanding of the **modelling context** draws on the notion of context discussed in Mahr [2011]'s model of conception. Therefore, the modelling context is understood as all the elements considered relevant for the modelling

effort by the observer. It is important to keep in mind that the delimitation of relevant modelling context is not objective, but depends on observer’s judgement [Mahr, 2012]. As such, the modelling context acts as the background against which the meaning of model is established, thus underlying all the judgements made within the modelling process.

We characterise **modelling process** in terms of streams of activities leading to the creation of a purposeful model. Therefore, we abstract away from the specific organisation of these activities, e.g. number of sessions taken, the modality of interaction between participants, use of particular modelling tools, etc. Hereafter, the entire timespan and all the activities taking place in modelling are taken into account and referred to as modelling process. At such level of consideration, we identify three essential streams in a modelling process (Figure 4.3):

- **Conceptualisation**¹²,
- **Manifestation**¹³, and
- **Evaluation**.

Although these streams are typically interrelated and not clearly differentiated in a real modelling process, this distinction is hereafter kept for analytic purposes.

Let us consider the proposed streams within a modelling effort $\langle mc, O, p \rangle$. Similarly to [Frank, 2011b], note that we do not consider **purpose** and **domain**, to be fully known and stable *a priori*, i.e. at the start of the modelling process, but that the clarification of both domain and purpose occurs throughout the very act of modelling.

4.5.2 Conceptualisation Stream

The conceptualisation stream refers to the stream of activities in which the observer **O** delimits the relevant ‘aspects’ of the world under consideration, and conceives the domain **d**.

Obviously, the core of the process of conceiving domain **d** consists in setting/choosing the perspective and identifying relevant ‘parts’ or ‘aspects’ of the considered world within the given **mc**. As also noted in our previous discussions in Section 4.2, it is crucial to note that this activity is always bound to the particular context, with its observer and goals of modelling [Karbe, 2011,

¹²We draw the attention of a reader to the fact that, in our publications until 2015, we used to label this stream as *Abstraction stream*. However, our discussions in Section 4.2 clearly point to a slightly different, and more mature, understanding of the role of abstraction mechanism in modelling, whereby abstraction is considered but one of the mechanisms used in modelling.

¹³The term manifestation is chosen over the term ‘representation’ in order to emphasise the gradual manifesting as a process, and to avoid the redundancy, as the term representation is used to refer to the established relationship between model and conceived domain, see Figure 4.3.

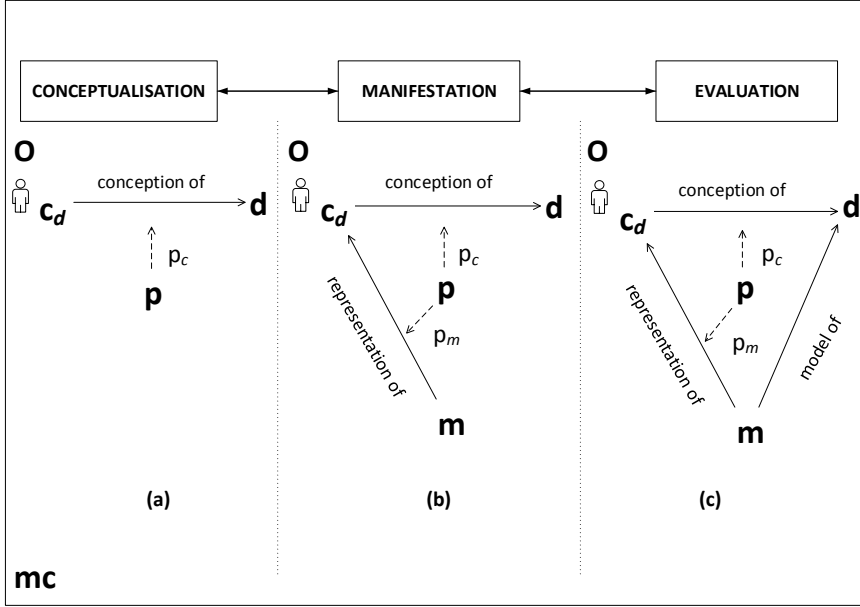


Figure 4.3: Essential streams of the modelling process

Mahr, 2012]. Consequently, within the conceptualisation stream, the domain d cannot be conceived independently of the modelling context mc , and regardless of the intended usage and audience, i.e. purpose p . For this very reason, we do not consider justified to define the *purpose* and *domain* independently from each other.

This activity yields observer's **conception of the domain** c_d and the relationship *conception of* (see Figure 4.3a). Note that the differentiation between c_d and d is in a way artificial, and is only kept for analytic purposes. In essence, c_d is d . The domain d is not independent from the mind of O , it exists only through being conceived of by O , and this in dependence on p , in the background of mc .

The delimitation of the domain d (and thus the content of c_d) depends on the perspective taken, observer's judgement of the relevance of some 'aspects' of the world for mc and p . As pointed out in [Stachowiak, 1972], strictly speaking, the selection of relevant 'aspects' of the world does not always follow the purposefulness criterion. In our work, we assume that the observer tends to *purposefully* conceive the domain, and we therefore exclude from consideration the potential conscious *political intentions* underlying the observer's judgement. This characterizes the influence of purpose p on the relation *conception of*, which is illustrated as p_a in Figure 4.3a.

4.5.3 Manifestation Stream

Manifestation stream refers to the shaping of an artefact (i.e. model-to-be) \mathbf{m} in such a way that it **represents** the domain \mathbf{d} for purpose \mathbf{p} .

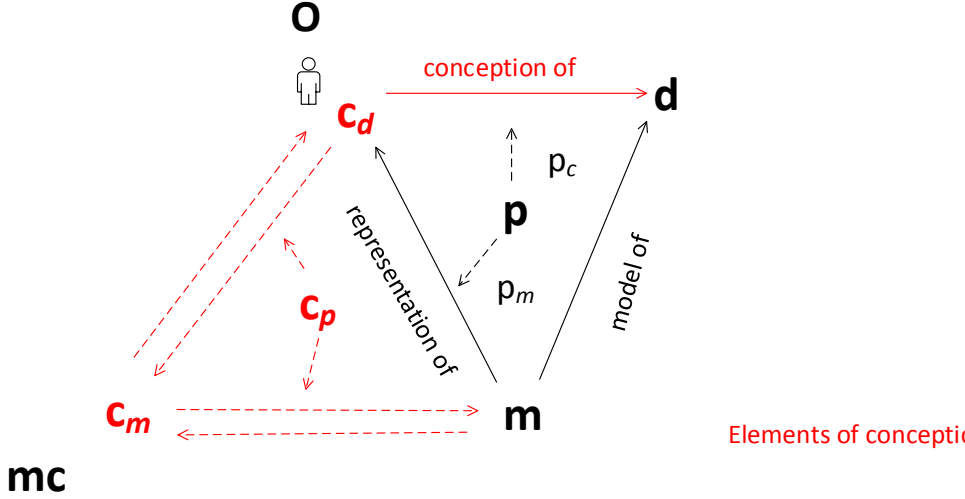


Figure 4.4: Aligning of conceptions

In line with the discussions in Section 4.2.4, we consider that when shaping an artefact \mathbf{m} , observer \mathbf{O} does so taking into account two dimensions:

1. The artefact model-to-be \mathbf{m} is shaped having in mind the ‘properties’ of the conceived domain \mathbf{d} (similar to cargo in [Mahr, 2009]), which are to be represented in it,
2. The required ‘properties’ of a physical manifestation of the artefact \mathbf{m} , with respect to enabling the intended use of the model-to-be by the intended audience, i.e. with respect to the purpose.

In other words, the shaping of an artefact \mathbf{m} is influenced by the model’s purpose \mathbf{p} . This influence of purpose \mathbf{p} on the *representation of* relationship is illustrated as \mathbf{p}_m in Figure 4.3.

At this point, one should observe that domain \mathbf{d} ‘exists’ by the fact that it is being conceived of by an observer \mathbf{O} , and in dependence on \mathbf{mc} and \mathbf{p} (similar to propositions of [Karbe, 2011, Mahr, 2011]). In fact, observer’s understanding of the purpose \mathbf{p} is essentially a conception as well, i.e. the conception of the purpose of the model-to-be \mathbf{c}_p . Even more, the observer \mathbf{O} also forms the conception of model-to-be, \mathbf{c}_m . This is illustrated in Figure 4.4. The heart of modelling thus actually consists in gradual alignment of these three conceptions (i.e. \mathbf{c}_d , \mathbf{c}_p , and \mathbf{c}_m) by \mathbf{O} , in parallel with the very shaping of the artefact \mathbf{m} . Therefore, potentially neither of conceptions is stabilised before the artefact \mathbf{m} is shaped in a satisfactory manner. The crucial step in this gradual alignment of conceptions is the observer’s evaluation of the *fitness-for-purpose* of \mathbf{m} .

In Figure 4.4, we use colour coding to emphasise, in red colour, the entities which are residing in the observer’s mind. Note that both domain **d** and purpose **p** are marked in black in the above-mentioned figure, and this is for the following reason. We can say that both domain **d** and purpose **p** obtain, through the process of modelling, their ‘relative objectivity’ within the scope of the given modelling effort, through the fact that they are discussed, reflected on, mutually aligned, and agreed upon in varying degrees by the observer **O**. In other words, they become ‘materialised by’ a conscious judgement (or consensus) of an observer **O**.

While that judgement is obvious in the case of an individual observer, it is more challenging in the case of collaborative modelling. In this setting, an observer **O** consists of a group of **n** human actors supposed to *jointly* conceive some domain **d** and come up with its model **m**, for the purpose **p**. The major challenge in collaborative modelling consists in the fact that **c_d**, **c_m**, and **c_p** may be very differently shaped for each individual human actor. Typically, this is affected by the pre-conceptions [Hoppenbrouwers et al., 2005b] of each actor, as well as their specific concerns with regards to the **mc** and **m**. This implies that, potentially, there can be *n* different sets of conceptions at play in the given **mc**. In order to reach a shared view on the **d**, **p** and **m**, the co-alignment of these *n* sets of conceptions potentially has to take place. This co-alignment should be *sufficient* for the actors to jointly acknowledge the artefact **m** as a *commonly agreed model*. This indeed is considered as a critical step in collaborative modelling [Rittgen, 2007].

4.5.4 Evaluation Stream

Evaluation stream refers to the continuous evaluation of the *fitness-for-purpose* of the artefact **m** by the observer **O** throughout the modelling process, and resulting in the final evaluation, i.e. the *judgement* by which model-being [Mahr, 2009] of an artefact is finally established. When **m** is finally evaluated as *fit* for **p**, it comes to be acknowledged, by the observer **O**, as model **m** for **p**. It is only at this point that the relationship *model of* comes into being (Figure 4.3c).

In this context of evaluation, the adequacy of both *representation of* and *conception of* relationship are at stake in the evaluation stream. It is also important to underline that the artefact **m** acts as a model only for the given **mc** and **p**, i.e. the model **m** has its *model-function* only for the given purpose **p**, and only while the observer **O**’s judgement holds (similar to pragmatic model-function of [Stachowiak, 1972]), namely:

This implies that, for a different purpose, the ‘same’ domain might require a different physical manifestation, in dependence on the intended use and audience, i.e. a different model.

Fitness for purpose. We embrace the view that *fitness-for-purpose* primarily refers to the utility of the artefact **m** for the intended purpose **p** [Kaschek, 2013, Rothenberg, 1989]. In our view, the notion of the utility can be essentially equated to the trade-off between the expected value of using the model **m** for

the intended purpose **p** and the costs involved in its creation [Bommel et al., 2008, Rothenberg, 1989], referred to as cost-benefit ratio in [Rothenberg, 1989].

Essential role of purpose. Given the previous discussions, it is obvious that the model purpose **p** influences all the key steps of modelling in a non-trivial way, and is also central to establishing the *model of* relationship. As the model-being [Mahr, 2009] of an artefact depends on the observer's judgement, it is essential that this judgement is explicitly made and that it is reasonably justified. In line with [Rothenberg, 1989, Thalheim, 2013], we take the position that the purpose should be made explicit when creating and using models. At least the model creator should be aware of the intended usage and audience of the model. In other words, the purpose may also need to be considered explicitly, i.e. purpose should be modelled. Explicitly considering the purpose may enhance its understanding by the observer, facilitate the alignment of conceptions in modelling, as well as force to make more explicit cost-benefit trade-offs in the evaluation of fitness-for-purpose of a model.

4.6 Summary

In this chapter, we have exposed and justified the proposition of the fundamental view on models, modelling and specifically role of purpose. This theoretical contribution is developed from a socio-pragmatic constructivist stance, and results from the critical synthesis of the related work. In the thesis, the developed fundamental view on modelling answers **RQ 1**, and lays the conceptual foundation for the study of the role of conceptual modelling language and its use in enterprise modelling context, i.e. for answering **RQ 2** and **RQ 3**.

CHAPTER 5

Conceptual Knowledge, Language and Conceptualisation

Based on the developed view on modelling (Chapter 4), we are interested to look more closely at the role of conceptual modelling languages. In this Chapter, we expose the relevant material from the chosen reference disciplines, which serves as the grounding of our fundamental view on the role of conceptual modelling language (Chapter 6). To this end, in Section 5.1, we expose our motivation and justify the selection of reference disciplines. Thereafter, we discuss the contributions from our chosen reference disciplines is exposed in Sections 5.2 and 5.3. The chapter is closed by a short summary and discussion of relevant insights gained.

5.1 Motivation and Reference Disciplines

Traditionally, the emphasis in conceptual modelling language studies has been on its formal definition and qualities that enable mechanical manipulation of models. While legitimate, this focus narrows down the concerns involved in language engineering, and undermines the challenges related to the role and use of engineered language within conceptual and in particular enterprise modelling [Falkenberg et al., 1998, Frank, 2011b, 2014b, Wyssusek, 2004, Wyssusek et al., 2001c, Wyssusek, 2006]. Besides acting as carrier for (mechanical manipulation of) models, a conceptual modelling language with its *conceptual foundation* is intended to ‘filter’ the view to adopt on a domain of interest in modelling. Furthermore, it is also intended to transfer specific knowledge or some ‘best practices’ in the application. It is often assumed that this ‘filter’ functions as intended, regardless of the variety of contexts, users and purposes for which modelling language is to serve. This, however, is too simplistic and mechanistic assumption.

Based on the introduced constructivist model notion (Chapter 4), we have

seen that both the shaping of conceptualisation and of the model as artefact is dependent from the context, perspective taken on the domain of interest, and purpose for which model is produced. This also calls for a better fundamental understanding of the role and functioning of conceptual modelling language in relation to these processes. How can a conceptual modelling language effectively influence and guide the conceptualisation within a particular modelling context? What is core competence of a modelling language, what are the limits and challenges of an engineered, or even standardised, language?

To answer such questions from a perspective that goes beyond a narrow normative orientation on conceptual modelling languages, we first seek a more fundamental understanding of interaction between language, conceptual knowledge and conceptualisation. This theoretical understanding is sought within the existing body of knowledge in the disciplines of **functional linguistics** [Clark, 1993, Cruse, 2011], **cognitive linguistics** [Geeraerts, 2010], and **cognitive science** [Baddely, 2012, Lakoff, 1987]¹. The choice of these **reference disciplines** is inspired by [Frank, 1998, Hoppenbrouwers et al., 2005a, Thalheim, 2012, Wyssusek, 2004, Wyssusek et al., 2001c]. In using these disciplines as our grounding, *we adopt a **working hypothesis** that human use of conceptual modelling languages in conceptualisation is subject to principles that underlie the formation, evolution and use of conceptual categories in natural languages.*

Note that, in formulating this hypothesis, we however do not assume that natural languages and conceptual modelling languages share the same structure or accommodate the same spectrum of usages. Obviously, the natural language grammar contains elements such as e.g. adverbial, pronouns, tenses, declinations, etc. which of course are not present in conceptual modelling languages. In addition, natural language also accommodates a wider range of conceptualisation and communication situations than covered by conceptual modelling languages, given their more specific focus. Our assumption is that by drawing the parallel at the level of conceptual organisation and use of concepts in conceptualisation, i.e. with respect to conceptual knowledge, we can much better understand the processes and principles that govern the use of conceptual modelling languages. Hence, we draw on contributions from the adopted reference disciplines which tackle the subject of how human mind stores and uses conceptual knowledge in natural languages.

Finally, the combined grounding in these disciplines is better understood if one is aware that the boundary between them is not so clear cut (See e.g. [Geeraerts, 2010, Chapters 20 and 49], and Section 3.2 of the thesis). Cognitive linguistics, primarily through the work of [Johnson, 1987, Lakoff, 1987], is used as our main reference discipline, while other contributions are used to complement and broaden the scope of discussions, where necessary.

¹How this orientation stands compared to other perspectives on modelling language phenomena within our field of research is discussed in Chapter 6.

5.1.1 Position of Cognitive Linguistics

As a discipline, cognitive linguistics emerged in late seventies and early eighties of the twentieth century, through the work of [Lakoff, 1987, Lakoff and Johnson, 1980, 1999, Langacker, 1987].

The fundamental position of cognitive linguistics consists in studying natural language as embedded in overall cognitive abilities of humankind: “Language can best be made sense of by recognizing that it is structurally and functionally continuous with, motivated by, and emergent from nonlinguistic cognitive processes” [Geeraerts, 2010, p. 1287]. To better understand the origins and foundations of this discipline from the historical perspective, it should be taken into account that it emerged as a critical response to the Chomskyan orientation in linguistics. The latter orientation isolates language from the rest of human cognitive apparatus, and focuses on grammar and formal rules of language organisation as primary phenomena of interest (for more details, see [Geeraerts, 2010, p. 11-15] [Taylor, 2010]). Cognitive linguistics, such as founded in the work of [Lakoff, 1987, Lakoff and Johnson, 1980, 1999, Langacker, 1987], focuses on language as an instrument for organising, processing and conveying information. “Given this perspective, the analysis of conceptual and experiential basis of linguistic categories is of primary importance within Cognitive Linguistics: the formal structures of language are studied not as if they were autonomous, but as reflections of general conceptual organization, categorization principles, processing mechanisms, and experiential and environmental influences” [Geeraerts, 2010, p. 3].

Within cognitive linguistics, semantics is given the primacy in linguistic analysis, and categorisation is studied as the main function of language [Lakoff, 1987]. However, this discipline does not study semantics and grammar as independent from each other, rather semantics is considered as having a central place in architecture of grammar [Langacker, 2010]. Linguistic structure (both semantics and grammar) is considered to be rooted in, arising in and interacting with actual use of language.

From the epistemological point of view, cognitive linguistics sees linguistic structure (and in particular categorial structures) as having a mediating role in interaction between ‘subject’ and ‘object’, and is interested in how this structure affects conceptualisation and contributes to the knowledge of world. As a *non-objectivist theory* of language, it does not see language as constituting an objective description of the world (construed from the point of view of an omniscient observer), rather language helps organise knowledge in a way that reflects the needs, interests, and experiences of individuals and cultures [Geeraerts, 2010].

Such an orientation on linguistic phenomena is considered as particularly adequate for our research subject, and relevant for answering research questions **RQ 2** and **RQ 3**.

The following discussion is focussed on understanding the structure of conceptual knowledge in language, and functioning of conceptual systems in relation to conceptualisation, as one of the main functions of language. We will first review, in Section 5.2, the essential aspects of the nature of conceptual systems and of their organisation in language, mainly based on the

work of Lakoff [1987]. Based on these elements, the functioning of conceptual systems in language use, and specifically in relation to conceptualisation, will be reviewed in Section 5.3.

5.2 Structuring of Conceptual Knowledge

The following notions, illustrated in Figure 5.1, are essential for understanding the structuring of conceptual systems in language, and are in the focus of present section:

1. **Embodiment as foundational premise** – The premise of embodiment lies at the core of much of modern research within cognitive science. More specifically, in cognitive linguistics, the notion of embodiment is in the focus of explanation of how human physical, cognitive and social embodiment grounds our conceptual and linguistic systems. We discuss the notion and dimensions of embodiment relevant in cognitive linguistics in Section 5.2.1.
2. **Pre-conceptual cognitive structuring principles** – The basic organising principles of all human cognitive processes, as claimed by [Johnson, 1987, Lakoff, 1987], arise as recurrent structural patterns from few basic domains of experience (mostly of bodily nature). They act as fundamental cognitive structuring devices in that they impose an organising structure (via metaphorical projection) to all our cognitive processes. Also known as *basic-level structures* [Lakoff, 1987], these structuring principles are subject of our discussions in Section 5.2.2.
3. **Cognitive models and conceptual systems** – According to Lakoff’s *cognitive model theory*², *idealised cognitive models* lie at the core of formation of human concepts, organisation of conceptual systems, as well as language. In Section 5.2.3, we introduce this notion and discuss, in Section 5.2.4, how it allows us to understand and characterise concepts and conceptual systems organisation.

5.2.1 Embodiment as Foundational Premise

In cognitive linguistics, the claim that the organisation of conceptual and linguistic systems is a consequence of the way how human cognitive apparatus is organised and how it functions in the environment is widely accepted, and is known as the **embodiment hypothesis** [Rohrer, 2010]. Historically, the hypothesis of embodiment originates from the research on metaphors and categorisation [Johnson, 1987, Lakoff, 1987, Lakoff and Johnson, 1980, 1999]. Studying linguistic metaphor, Lakoff and Johnson discovered that metaphors

²Although several similar theories have been developed [Cienki, 2010] with the aim to characterise the basic principles of organisation of conceptual knowledge, the particularly influential theory for the study of categorisation is *cognitive model theory* [Lakoff, 1987]. It synthesises prominent research in cognitive science/cognitive linguistics of the time.

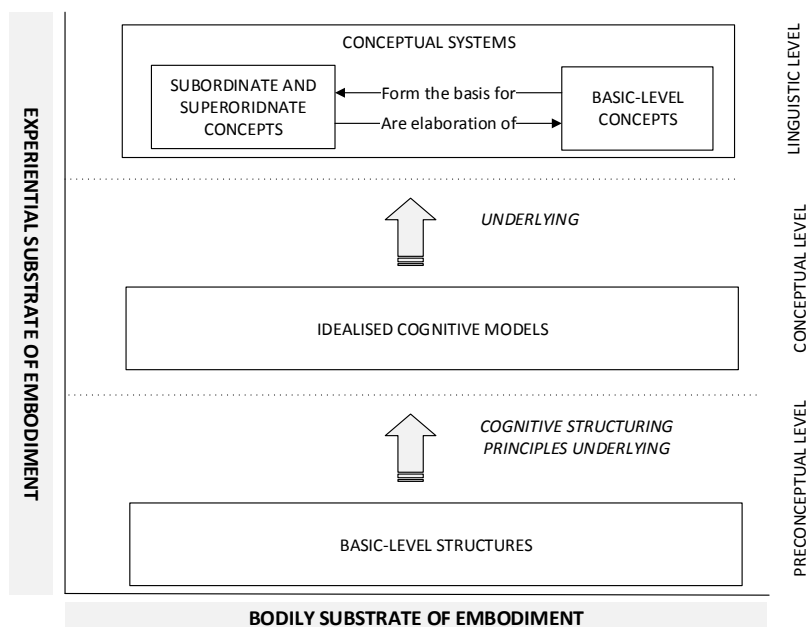


Figure 5.1: Structuring principles of conceptual knowledge and language

are pervasive in human cognition, and have a central place in the organisation of conceptual and linguistic systems.

Another important finding was that a vast majority of metaphors draws on the domains of bodily experience (e.g. the experience of inhabiting the body, moving the body in space, etc.; hence *embodiment*): human mind uses the structure of bodily domains of experience, to impart an organising structure, via metaphorical projection, onto more abstract domains of experiences [Johnson, 1987, Lakoff, 1987, Lakoff and Johnson, 1980]. With the development of research on this topic, the embodiment has been broadened to be discussed along two main dimensions [Rohrer, 2010]:

- **Embodiment as bodily substrate** – This dimension refers to the universal neurobiological and physiological bodily interactions with space, which are used as basic structuring principles of human knowledge and language;
- **Embodiment as broadly experiential** – This dimension refers to cultural and historical context in which human cognition and language are situated, and the influence that human experience within social context have on shaping human knowledge and language. This dimension has been less integrated in initial cognitive linguistics research [Rohrer, 2010].

5.2.2 Cognitive Structuring Principles

The *basic-level structures* are defined as *recurrent* and *pervasive patterns* emerging from everyday human experiences, and serving as structuring devices in human cognitive processing. The basic-level structure typically emerge from the following distinct domains of experience (aka basic domains of experience):

- Perceptual interactions with the environment,
- Experience of body and movement in space,
- Manipulation of objects within space

These structures are *pre-conceptual*, as they arise developmentally prior to conceptual thinking, but also because in terms of cognitive processing they precede concept formation. Because of their lack of content and specificity (they are mainly perceptual and topological in nature), these structures are *embodied* and *directly meaningful* to human mind. These characteristics make basic-level highly flexible cognitive tools. Some of the most fundamental basic-level structures, named *image schemas* [Johnson, 1987] are, for instance: CONTAINER, BALANCE, BLOCKAGE, COMPULSION, COUNTERFORCE, ENABLEMENT, ATTRACTION, MASSCOUNT, RESTRAINT REMOVAL, PART-WHOLE, MERGING, SPLITTING, PROCESS, SURFACE, OBJECTS, COLLECTION, etc.

Image schema of CONTAINMENT

For instance, CONTAINMENT is one of the most fundamental basic-level structures. Oakley [2010, p. 226-227] discusses that the shaping of CONTAINMENT as a basic-level structure depends on socio-cultural factors. “Unlike Danish- and English-acquiring children, who, for the most part, are born into a world of richly diverse set of artifacts, each of which perform highly specific functions, Zapotec-acquiring children grow up in material cultures with few artifacts, and, therefore, make use of them in more flexible ways. One salient artifact in Zapotec cultures of southern Mexico is baskets. The child enters a world in which baskets are used as often to *cover something up* (e.g. tortillas, for storage, for catching chickens) as they are used to *place an object in*. The inverted orientation of the basket is a defining art of their material culture. In Zapotec culture, containment via baskets counts equally in its inverted “orientation” (under) as it does in its canonical orientation (in)” [Oakley, 2010, p. 227].

The example of CONTAINMENT image schema illustrates the universality of basic-level structures in human experience. It also points at the fact that different (non-linguistic) practices within a specific material culture have an influence on how the fundamental structure will be used as for structuring concepts and language.

5.2.3 Basic Organising Unit of Conceptual Knowledge: Idealised Cognitive Models

According to Lakoff's cognitive model theory [Lakoff, 1987], human thought, knowledge and language are all organised by means of idealised cognitive models (ICM). These models have been a foundational notion for numerous contributions in cognitive accounts of language, and specifically valuable as an analytic tool in studying categorisation [Cienki, 2010, Lakoff, 1987]. Essentially, an **idealised cognitive model** constitutes a *coherent cognitive unit*, which emerges as a *gestalt*, a complex coherent whole³, and structured based on the fundamental *cognitive structuring principles* (Section 5.2.2).

Idealised nature. An ICM emerges as a *representative of some ideal case within the given domain of experience*. Having an *ideal case* at its very basis, they inherently *abstract away* from the complexities and specificities of the world: the ideal case is defined with respect to some *background assumptions*, i.e. presuppositions, which are an oversimplification of the possible variety found in the 'real world'. Lakoff argues that this characteristic of ICM is a fundamental source of all the prototype effects in language [Lakoff, 1987]. This is illustrated in the following example of a cognitive model that underlies the characterisation of the concept of a bachelor (See example below).

Perspectival nature. The *background assumptions* based on which the ideal case at the heart of ICM is identified refer to a certain *frame of knowledge* [Cienki, 2010], i.e. they reflect a *particular perspective on the domain of experience*, which an ICM inherently embodies. The ability to conceptualise same domains of experience in different ways, with respect to different frames of knowledge, as well as at varying levels of abstraction, granularity, various degrees of subjectivity-objectivity [Cruse, 2011, Verhagen, 2010] is reflected in all languages. In [Lakoff, 1987], Lakoff demonstrates that it is actually quite common that within the same domain of experience, different ICMs capture different (sometime even mutually conflicting) perspectives, and store conceptual knowledge about that domain of experience at differing levels of details. This is illustrated in the following.

³*Gestalt perception* refers to the capacity of human perception to isolate certain shapes from the other shapes in the perceptual space. The isolated shapes are processed as coherent wholes, i.e. single cognitive units. This does not necessarily imply that that which is processed as a gestalt does not have any internal complexity, but rather that it has a particular cognitive significance when viewed as a coherent whole [Cienki, 2010]. In his work, Lakoff argued that gestalt structures underlay all of human cognitive processing, including perception, emotion, motor activity, as well as thought and language [Cienki, 2010, Lakoff, 1987]. As we will see in the following, basic-level structures, idealised cognitive models and basic-level concepts are all considered to have gestalt properties: they do have an internal structure (e.g. container has interior and exterior and boundary), however their components are not per se meaningful when seen as isolated from the whole.

Bachelor ICM

The notion of an idealised case and background assumptions and their utility in understanding how meaning of a concept (e.g. bachelor) is defined can be demonstrated on Lakoff's analysis of a bachelor ICM [Lakoff, 1987, p. 70]. The concept of *bachelor* is typically understood as an *unmarried adult man*. Its understanding actually entails the background assumptions of a society with typically monogamous marriage, and a typical marriageable age. These background assumptions are oversimplified with respect to the 'reality', in which there are unmarried adult men who would not qualify as bachelors, e.g. priests, or men who live in long-term unmarried partnerships, and would not be categorised as such, although they are unmarried and adult. This is also used as an example that feature-based category definitions do not correspond to the way human generally categorise. Cognitive model theory proposes that the concept of bachelor is defined based on an ideal case, that is, a characterisation of the prototypical bachelorhood within a given socio-cultural context. This ideal case lies at the core of bachelor ICM. "*The background conditions of the bachelor ICM rarely make a perfect seamless fit with the world as we know it. Still we can apply the concept with some degree of accuracy to situations where the background conditions don't quite mesh with our knowledge. And the worse the fit between the background conditions of the ICM and our knowledge, the less appropriate it is for us to apply the concept*" [Lakoff, 1987, p. 71].

Frames of knowledge and perspectives: stars example

To illustrate how different frames of knowledge relate to different perspectives from which a domain of experience may be conceptualised, the example of different ways of characterising the spatial distribution of stars on the sky is discussed in [Verhagen, 2010, p. 49]: "[...] a particular distribution of stars is only considered a *constellation* in a culturally shared traditional frame of knowledge about the structure of the sky, while this framework is not required for conceptualizing it as a [...] *cluster of stars* and *specks of light in the sky* [...]. Then again, *specks of light in the sky* (with the plural noun *specks* as its head) focuses on multiplicity of the phenomenon observed, whereas *constellation* and *a cluster of stars* impose the construal of a coherent unit..." [Verhagen, 2010, p. 49].

Economy and evolutionary advantage of ICM. The structuring of human knowledge in terms of ICM has both an evolutionary and economy advantage:

- From an *evolutionary perspective*, ICMs arise and evolve based on self-coherent and directly embodied pre-conceptual structures (Section 5.2.2), the use which allows us to make sense (i.e. organise cognitive processing) of our experiences. This allows the humankind to accumulate knowledge about the previous experiences and reflect about the possible ones, and make the emergence of language possible, for these experiences and

knowledge to be shared and communicated about.

- From the *economy perspective*, ICMs provide human mind with ready-made ways to pre-structure conceptualisations [Fauconnier, 2010] [Lakoff, 1987, p.68], and thus optimise cognitive processing of our encounters and experiences within the world. We discuss this aspect in Section 5.3.3.

5.2.4 Concepts and Conceptual Systems

The relevance of cognitive model theory lies in its power to explain a wide range of semantic phenomena: ICM allow to characterise the overall category structures, to indicate central members of a category, as well as to provide a cognitive account of concepts semantics⁴. We will discuss the contribution of this theory towards understanding the structuring and use of concepts and explaining their semantics.

Internal structure of an ICM. An ICM has a certain (internal) structure, consisting of its elements and relations. In general, the *elements of an ICM* are *concepts*, either basic-level concepts or concepts which are defined by another ICM. The *relational structure* both within an ICM and across different ICMs is established by the metaphorical projections of all kinds of basic-level structures. Therefore, these structures are not only responsible for human cognitive processes, but also for the emergence of entire conceptual systems in languages.

Furthermore, the relational web between different ICMs and their elements can be quite complex. According to [Lakoff, 1987], this complexity is a common case in human languages. We illustrate this using Lakoff's analysis of mother ICM, given below. In this example, several ICMs combine in a cluster (via different metaphorical projections), and such cluster ICM underlies the understanding of both a main (basic-level) concept of mother and its different elaborations.

Basic-level concepts. The most rudimentary structured ICMs underlay basic-level concepts. They stand for:

- Conceptual-linguistic manifestation of the pre-conceptual basic-level structures, or
- Concepts standing for physical objects that we interact with in our everyday experiences.

⁴In his work, Lakoff makes distinction between purely conceptual and symbolic ICMs. A purely conceptual ICM can be characterised independently of the morphemes of particular language. In turn, when linguistic forms are associated to conceptual elements in the ICM, such ICMs are referred to as *symbolic ICMs* [Lakoff, 1987, p. 289-292]. Symbolic ICMs are relevant in the analysis of meaning of lexical items – words and expressions – as well as grammatical categories and constructions. In our discussions we have the focus on concepts in language. It is evident that ICMs we refer to are always symbolic ICMs. We will thus not explicitly separate purely conceptual from symbolic ICMs.

Basic-level concepts are important for cognitive processing as they are the most central “relative to a variety of psychological criteria: gestalt perception, the ability to form a mental image, motor interactions, and ease of learning, remembering and use” [Lakoff, 1987, p.56]. As such, they constitute an ideal ‘raw’ material the elaboration of a conceptual system [Lakoff, 1987, Lewandowska-Tomaszczyk, 2010, Schmid, 2010]. In a developed conceptual hierarchy, basic-level concepts are usually – but not always – found ‘in the middle’, they are central to the category. However, given that conceptual hierarchies interact with language use, and depend on non-linguistic practices and experiences within a material culture, it is also possible to find the concepts with the basic-level status towards the ‘periphery’ of a category hierarchy.

Basic-level concepts: examples

In the ‘category hierarchies’ *Animal-DOG-retriever* and *Furniture-CHAIR-Rocker*, concepts of DOG and CHAIR are situated at the basic-level of experience, because they stand for the level of interactions with the objects which lies in the scope with our daily interactions with the world. This is also the typical example of basic-level concepts in the ‘middle’ of a hierarchy.

To illustrate the peripheral cases of concept acquires basic-level status, as they gain on cultural importance, Schmid [2010, p. 125–127] discusses the following examples. Namely, in language, concepts (*motor*)*car* and (*air*)*plane* started as subordinates in the vehicle category, but because of the material practices, these clearly acquired basic-level status. The same phenomena seems also to be observable in the category of clothing garments, where the jeans, when first appeared in the material cultures, started out as a subordinate of general pants category, but given the cultural importance of these kinds of pants, the jeans acquired basic-level status, i.e. became firmly entrenched concept.

Conceptual systems. Conceptual systems start developing around the basic-level concepts. Typically, the elaboration of basic-level concepts is motivated by:

- The extension of basic-level concepts to cater for specific cases – Both subordinate and superordinate categories are motivated as the extension of basic-level concepts, and essentially characterise the elaborations of specific cases or exceptions of the *ideal case* underlying the basic-level concept. This kind of conceptual elaboration is illustrated in the example of ICM underlying mother category.
- The metaphorical projection of basic-level concepts to understand and structure more abstract domains of experience – In Section 5.2.1 and 5.2.4, we have already mentioned the finding of [Lakoff, 1987, Lakoff and Johnson, 1980] that human brain understands abstract concepts indirectly, based on the metaphorically projecting basic-level structures to organise cognitive processing of more abstract domains of experience.

Mother ICM and elaboration to subordinate concepts

According to [Lakoff, 1987, p. 74], the concept of mother is defined based on several individual ICMs, which combine into a coherent whole (referred to as **cluster model** by Lakoff). Taken as a whole, these individual models are psychologically more basic than the individual ones, which motivates their blending into a single cluster ICM. Lakoff lists ICMs contributing to the definition of mother concept are:

- Birth model, where mother is defined as the person who gives birth.
- Genetic model, where mother is the person providing genetic material.
- Nurturing model, where mother is defined as the person who nurtures and gives rise to a child.
- Marital model, where the mother is defined as the wife of a father.
- Genealogical model, where the mother is defined as a closest female ancestor.

These models all come with certain background assumptions, but more than one of these contributes to the characterisation of the concept of mother. The *ideal case* of a mother is the one in which all these individual models converge, however a mother may be a person in which this case of ‘total convergence’ is lacking. The cases of divergence give rise to the expressions like stepmother, adoptive mother, surrogate mother, biological mother, foster mother, etc. Lakoff underlines that these are not just simple subcategories, i.e. kinds, of ordinary mothers, because there may be no common features across these sub-cases. These sub-cases are all characterised as mothers by virtue of their relation to the ideal case, the one where individual cognitive models in the cluster converge.

Furthermore, in a situation where individual models underlying a cluster model (as in the case of mother category) are divergent, Lakoff discussed that there is a strong cognitive pull to view one of the individual models as a dominant. In [Lakoff, 1987], it is even shown that different dictionary makers choose different individual cognitive model as primary one for defining the concept of motherhood.

Abstract domains of experience and abstract concepts

To illustrate, in this context, pre-conceptual structures corresponding to our experience of space “define most of what we commonly mean by the term “structure” when we talk about abstract domains. When we understand something as having an abstract structure, we understand that structure in terms of image schemas” [Lakoff, 1987, p. 282]. In this context, Lakoff claims:

- Categories are in general understood in terms of CONTAINER schemas,
- Hierarchical structure in terms of PART-WHOLE and UP-DOWN schemas,
- Relational structure is understood in terms of LINK schemas,
- Radial category structure is understood in terms of CENTER-PERIPHERY schemas.

The structuring of concepts and conceptual system in terms of ICM has interesting implications for understanding the semantics of concepts, and this stands as one of the important contributions of cognitive model theory [Lakoff, 1987]. According to Lakoff [1987], the entire ICM, together with the relational structure, stands as the background against which the meaning of an individual concept in an ICM is characterised. In other words, any individual concept in ICM (conceptual system) is defined/understood with respect to the frames of knowledge and perspectives taken on the domain of experience captured in the ICM, and also having in mind the internal relational structure of an ICM as a whole. The case of mother concept and its sub-cases exemplifies it: the specific sub-categories of mother can only be understood and semantically characterised within the context of an entire cluster ICM (from the above-mentioned example) which characterises the concept of a mother.

Based on all the characteristics previously discussed, Lakoff [1987] characterises the essence of **universal human conceptualising capacity**, thus independent from cultures and languages, as consisting in:

- “The ability to form symbolic structures that correlate with *pre-conceptual* structures in our everyday experience. Such symbolic structures are basic-level and image-schematic concepts.
- The ability to metaphorically project from structures in the physical domain to structures in abstract domains, constrained by other structural correlations between physical and abstract domains. This accounts for our capacity to reason about abstract domains such as quantity and purpose.
- The ability to form complex concepts and general categories using image schemas as structuring devices. This allows us to construct complex event structures and taxonomies with superordinate and subordinate categories” [Lakoff, 1987, p. 281].

5.3 Functioning of Conceptual Systems

The basic-level structures, metaphorical projections and idealised cognitive models, enable us to characterise the organisation of conceptual knowledge in terms of concepts and conceptual systems. In this section, we focus on their functioning, and tackle the mechanisms underlying their formation, refinement and finally their use, specifically with respect to conceptualisation. We first discuss, in Sections 5.3.1, cognitive mechanisms affecting differences in cognitive statuses of concepts in human mind. The consequence of this on the elaboration of conceptual systems is discussed in Section 5.3.2, and the impact on conceptual system variation, and their capacity to mediate conceptualisation is discussed in Section 5.3.3.

5.3.1 Schematicity, Entrenchment and Cognitive Salience

The *schematicity*, *entrenchment* and *salience* are the key cognitive mechanisms that underly the formation, memorising and use of concepts and conceptual systems.

Schematicity. The mechanism of schematicity [Langacker, 1987, Tuggy, 2010] characterises a fundamental human cognitive capacity of generalisation, which is pervasive in human thought. It emerges from a comparison between two mental structures, the recognition of their core commonalities, and abstracting away from the differences not relevant in the context of a specific cognitive task. Schematicity comparison results in establishing relations of schematicity between the compared mental structures, as illustrated in Figure 5.2. Both the schematicity comparison and relations of schematicity are:

1. **Relative** – the unfamiliar structure is always compared *against* the familiar, already memorised unit (there is always a *directionality of comparison*), and
2. **Contextual** – as the recognition of commonalities and abstraction of irrelevant details is not absolute, but related to the cognitive task at hand.

Schematicity comparison facilitates the formation of cognitive units in reasoning, i.e. in working memory (Note that the term *cognitive unit* used here is general, and can stand for basic-level structures, concepts, whole ICMs etc.). Different schematicity relations have a different effect on the formation of cognitive units:

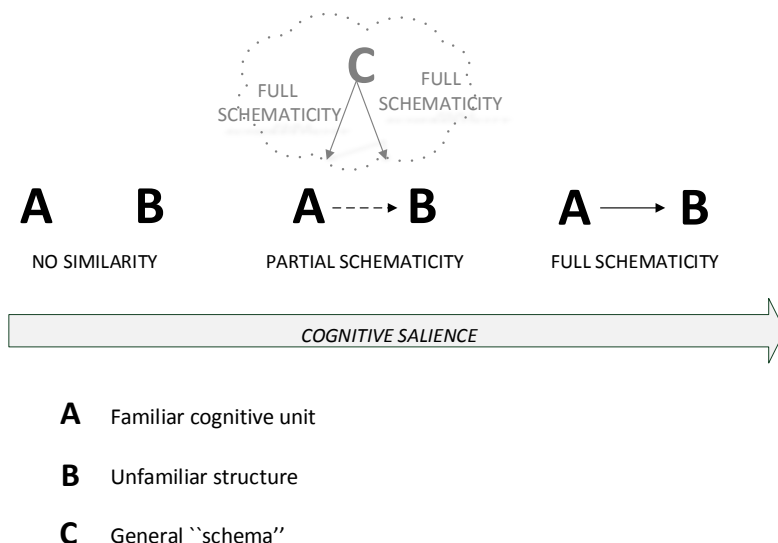


Figure 5.2: Schematicity relations and cognitive salience.

- **Full schematicity** occurs when a target structure **B** preserves all the features found in the familiar unit **A**, while also having some other different features. A more general structure **A** is typically referred to “schema”, and the more specific one, its “elaboration”.
- **Partial schematicity** occurs when the target structure **B** preserves some features but omits or distorts other features of **A**. The interesting cognitive property of partial schematicity is that it exercises a strong pull towards the creation of a general “schema” **C**, to encounter for the commonalities between compared structures of **A** and **B**. In this manner, partial schematicity lies at the core of the pull towards conceptual elaboration (Section 5.2.4). If the general schema **C** is cognitively important, and based on some coherent specifications of **A** and **B**, there will be a tendency to form a concept reflecting schema **C**. If this general schema **C** is also useful for conceptualisation/communication, it will tend to be fixed and memorised, i.e. entrenched in human mind.
- **No similarity** refers to the situation where schematicity comparison between **A** and **B** concludes that there is so much distortion between features of **B** and **A** that there is no sense to talk about their similarity at all.

While partial schematicity is by far the most frequent in human reasoning, the cases of schematicity are more cognitively important. Human cognitive apparatus reacts to the case of full schematicity relations with a heightened neural activation than in the case of partial schematicity [Tuggy, 2010, p. 86], which facilitates the simultaneous activation of both “schema” and the “elaboration” in reasoning. In the case of partial schematicity relations, the degree of neural activation correlates with the proximity of cognitive units compared in terms of their inherent characteristics: the more similarity between features of **A** and **B**, the higher neural activation.

Entrenchment. The repetition of schematicity comparison between the two cognitive units leads to their fixation in the mind and to their memorising in long-term memory, i.e. to the entrenchment [Schmid, 2010] of these cognitive units. The entrenchment is a matter of degree, and correlates with the *frequency of use* of a cognitive unit: the more it is used in processing (e.g. in conceptualisation or communication event), the more it is entrenched in human mind⁵. Furthermore, the more firmly a cognitive unit is entrenched, the more it behaves like a single *gestalt* in cognitive processing. This gestalt-like behaviour has a consequence that such unit, regardless of its internal structural complexity,

⁵From the perspective of cognitive linguistics, the conventionality of language concepts and constructions is explained in terms of their entrenchment, i.e. repeated use events that use or presuppose them. This applies both to individual speakers’ processes and to the entire speech communities. The cognitive unit initially present only in a speaker’s mind may become conventionally established as the usage events that presuppose or assert the unit occur. Likewise, the same mechanism applies to the acquiring of language by a new community member: conventionalised concepts, shared by the members of a culture, by virtue of being used in the speech, become entrenched in the mind of a new speaker.

requires little cognitive effort to process, which facilitates its combination with other structures.

Cognitive salience. The consequence of entrenchment is that it facilitates the reactivation of a cognitive unit in reasoning: the more entrenched cognitive unit requires less *cognitive effort* to be activated in reasoning [Baddely, 2012, Fauconnier, 2010]. The ease of activation of a cognitive unit is referred to as the cognitive salience of the unit.

A high degree of entrenchment correlates with a high cognitive salience of a unit, i.e. to its potential for automatic and effortless activation in reasoning. At the same time, each activation of the unit reinforces it and further entrenches it in the memory.

In this context, the schematicity relations existing between the activated unit and other cognitive units entrenched in human mind facilitate the activation of entire neural networks, not just single unit: every time one unit is activated, the units related to it with full and strong partial schematicity are also activated. In that sense, schematicity has an impact on the salience (and entrenchment) of not only single units, but also entire cognitive structures.

5.3.2 Elaboration of Conceptual Systems

As discussed in Section 5.2.4, the conceptual systems develop around the basic-level concepts, either as their elaboration of specific cases and extensions, or as the metaphorical projection from basic-level concepts to more abstract domains of experience. Basic-level concepts are the most firmly entrenched concepts in any language: they are first acquired in language development, and first enter the child's lexicon, and are subsequently repeatedly used in encounters with the world. The high degree of entrenchment and salience of basic-level concepts makes that they are automatically, unconsciously and almost effortlessly used in thinking [Lakoff, 1987, Schmid, 2010]. It is therefore not surprising, from the cognitive point of view, that such firmly entrenched units act as the structuring elements of conceptual systems and language⁶.

New structures in reasoning emerge via schematicity comparisons to basic-level concepts and other entrenched units. However, not all of the “schemas” and “elaborations” resulting from these comparisons (Section 5.3.1) become fixed as cognitive units and entrenched in minds of speakers, let alone enter the language of corresponding speech communities. Whether or not this happens is sanctioned by the combined effect of **cognitive** and **experiential factors**.

Cognitive factors. Essentially, this factor refers to the potential of a new structure to be admitted into a cognitive repertoire. This potential is determined by the similarity of a new structure (either in form or in content) to an

⁶In addition, according to [Lakoff, 1987], this is precisely the reason why the most fundamental and most firmly entrenched concepts tend to be grammaticised, i.e. to become part of the grammatical constructions and rules [Lakoff, 1987, chapter 18]. In that sense, in most cognitive accounts of language, grammar and semantics are actually seen on a continuum, which is usage-based. The continuum of grammar and semantics is, for instance, one of the essential claims within cognitive grammar [Langacker, 2010].

already firmly entrenched unit. The greater this similarity (ranging from partial to full schematicity, Section 5.3.1), the greater potential for a new structure to become part of the repertoire.

Experiential factor. Nonetheless, the *decisive factor* for new structure to become effectively part of cognitive repertoire (and ultimately language) is its *communicative usefulness*. Simply, if the new structure is motivated by some intrinsic characteristics and as such is communicatively useful, it is likely to recur in language processing and use events, hence it is likely to become entrenched, and at some point conventionalised in language [Schmid, 2010, Tuggy, 2010].

Consequently, when it comes specifically to superordinate (and abstract) concepts, these concepts should be motivated by some intrinsic characteristics of their subordinates *and* also be of use within a given speech community, otherwise they are not likely to enter cognitive and language repertoire. As a consequence of this principle, except for specific individuals and in specific speech communities, abstract concepts are a priori considered as much less likely to become strongly entrenched and thus cognitively salient in speakers' minds than other concepts that correspond to the more everyday domains of experiences.

5.3.3 Conceptual Systems and Conceptualisation

The influence of conceptual systems on conceptualisation, as well cross-linguistic variation between conceptual systems for a same domain of experience (such as widely known example of classification of colours across languages, etc.) and its effect on conceptualising experiences using different language/conceptual system is a topic with a long-standing history in philosophy and linguistics. These discussions are mostly centered around debates on the notion of linguistic relativity, and attempts of its empirical validation.

Linguistic relativity, widely known as *Sapir-Whorf's hypothesis* or *Whorfian hypothesis* [Lakoff, 1987, ch.18] [McAfee, 2004, Pederson, 2010, Tohidian, 2009] stands as a cover term for many different views on the nature of relationship between language, culture and thought, and has become popularised through the work of Sapir and Whorf in linguistics, to some extent also due to the controversy around Whorf's propositions [Lakoff, 1987, Chapter 18]. According to [Lakoff, 1987, Pederson, 2010], two main components underlying the notion of linguistic relativity are: 1) claim that languages vary in their expression of concepts in noteworthy ways, and 2) claim that linguistic(ally expressed conceptual) categories exert some influence, i.e. filter, over conceptualisation. With regards to the latter, the degree of influence over conceptualisation is taken as a basis for two common formulations⁷ of the Sapir-Whorf hypothesis, namely:

⁷Interestingly enough, however, these two formulations of Sapir-Whorf hypothesis disregard the dimension of conceptual variation, which was the focus of Whorf's work [McAfee, 2004] [Lakoff, 1987, Chapter 18].

- **Strong hypothesis** states that language *determines* thought,
- **Weak hypothesis** states that language *significantly influences* thought.

While *strong hypothesis* is rejected, the *weak hypothesis* has been subjected to empirical evaluations of different kinds [Pederson, 2010]. However, Lakoff [1987, Chapter 18] discusses that the variety of aspects have to be taken into account when formulating one's views regarding linguistic relativity. For the detailed discussion of these aspects, we refer the interested reader to Lakoff [1987, Chapter 18]. In the following, we will only cover some of these elements, that pertain to the variation in conceptual systems and their influence on conceptualising experiences, which is more directly related to the subject of our research.

Variation in Conceptual Systems and Effect on Conceptualisation

The variation between conceptual systems (in alike domain of experience) across different languages, but also within the boundaries of a single language, Lakoff sees as rooted mainly in different organisation and use of these conceptual systems. These variations, as we will see, have the effect on differences in conceptualisation of a domain of experience.

Conceptual Organisation

With respect to *conceptual organisation*, Lakoff [1987] considers these differences as arising from

- Differences in highly structured pre-conceptual experiences, rooted in different cultures and practices that language emerges from.
 - Differences in metaphorical projections used to understand target domains of experience, even with the same fundamental experiences. Indeed, the “experience does not determine conceptual systems, but only motivates them, the same experiences may provide equally good motivation for somewhat different conceptual systems” [Lakoff, 1987, p. 310]. Thus, even the same basic experience and same conceptualising capacities can give rise to some difference in conceptual systems.
 - Differences in the choices of conceptual organisation, as different pre-conceptual and basic-level experiences may act as dominant structuring principles which lead to different organisation of conceptual systems. Even when the basic-level experiences are seemingly universal, in certain cultures, some of these experiences may not have been conceptualised, and may lack corresponding linguistic manifestation. This also results in some difference between conceptual systems pertaining to same domains of experiences. “An extreme example of such “hypocognition” has been reported by Levy(1973). Tahitians, Levy found, not only do not have a word for sadness, they seem to have no concept of it and, correspondingly, no ritualized behavior for dealing with depression or bereavement. They appear to experience sadness and depression, but have no way to cope
-

with it. They categorize sadness with sickness, fatigue, or the attack of an evil spirit” [Lakoff, 1987, p. 310].

While the variation between different conceptual systems in terms of pre-conceptual schemas and basic-level structures is not radical (given their universality and bodily origin), the more significant variation occurs in the organisation of conceptual systems. Even within the same language, there is a systematic co-existence of different ways, even mutually inconsistent, of framing nearly the same domains of experience, manifested in differently organised conceptual systems [Lakoff, 1987]. “Alternative conceptual systems exist, whether one likes it or not. They are not likely to go away, as they arise from the fundamental capacity to conceptualise experience. Communication might be easier if everyone had the same conceptual system. But better communication would not eliminate conflicts of interest, which are the major sources of human conflict. I view relativist of the sort that exists as a good thing. Just as the gene pool of a species needs to be kept diverse if the species is to survive under a wide variety of conditions, so I believe that diverse ways of comprehending experience are necessary to our survival as a species [Lakoff, 1987, p. 336-337]”.

Use Dimension and Functional Embodiment

With respect to the **use dimension**, the difference between conceptual systems is also to be found in the way concepts are used. “*Concepts only exist by virtue of being embodied in a being. A conceptual system is a functioning organization of concepts. The way concepts are used is part of what defines the system.*” [Lakoff, 1987, p. 318]. Consequently, “if two conceptual systems contain the same concept but use it in different ways, then the systems are different” [Lakoff, 1987, p. 318]. This is the reflection of fact that concepts are only embodied as and in the way they are used, a characteristic labelled by Lakoff as functional embodiment or embodiment-of-use of concept/conceptual system.

The notion of functional embodiment emphasizes that it is not enough to just learn and understand a concept, in order for it to be used *in* thinking and processing experiences. Concepts that are novel to mind are pondered as *objects of thought*, clarified, approached from different angles, etc. to first be understood, and then eventually effort-fully and deliberately used in conceptualisations. Novel concepts are much less likely to be used *in thought*, while functionally embodied concepts are spontaneously, instantaneously and unconsciously used in our reasoning and understanding of experiences, and as such have greater impact on how we process experiences. “The difference is one between thinking *in* the language and translating *into* the language” [Lakoff, 1987, p. 320].

Therefore, the *cognitive status* of concepts and entire conceptual systems (Section 5.3.1) is inherently related to their *usage*, i.e. it is intimately linked to the way they are used within specific communities’ experiences and practices (experiential dimension of embodiment). While, in one community, certain concepts may be more central within language, in other communities, these concepts may even not be a part of cognitive repertoire in a different community. Therefore, the capacity of a concept or conceptual system to mediate thought

is crucially dependent on the extent of their functional embodiment⁸.

Effect on Conceptualisation

Storing of human conceptual knowledge in terms of ICM principles is considered to have the economy advantage (Section 5.2.4), as conceptual systems provide ready-made ways to pre-structure thought in conceptualisation processes [Fauconnier, 2010]. More concretely, the fact that conceptual structures are entrenched as coherent wholes (i.e. they have gestalt-like properties) optimises their activation and cognitive processing, and facilitates their re-use.

Now, concepts and conceptual systems are stored in long-term memory, while the conceptualisation processes occurs in the working-memory, and are highly dynamic. A conceptualised situation is always conceptualised within the given context, and in relation to the perspective taken on the domain of experience.

Within a given conceptualisation context, some *salient* elements of already entrenched ICMs may be triggered and activated into working memory. (If an element of an ICM is activated, then entire ICM is activated as well). In this context, and based on the previous discussion, a more entrenched and functionally embodied concepts or conceptual systems are obviously more likely to affect the conceptualisation than a dis-embodied ones.

Besides the cognitive factor, however, the choice of framing a given conceptualised situation also depends on the *fitness* of such framing for the given context and its objectives. Differently organised conceptual systems give rise to different conceptualisations, because of different perspectives taken on the domain of experience, related to the different background frames of knowledge (See examples in Section 5.2.4.)

It should, however, be borne in mind, that conceptual-linguistic constructions (here more narrowly concepts and conceptual systems) only *prompt* [Fauconnier, 2010] for certain constructions in context. They always leave space for filling in contextual details, and also allow for elaboration, revision and reconstruction of conceptual structures depending on the circumstances of a conceptualisation context. These refinements are governed by the cognitive mechanisms discussed in Section 5.3, as well as their entrenchment in the mind of individuals, and conventionalisation in minds of entire speech communities.

5.4 Summary and Discussion

The contributions we reviewed in Sections 5.2 and 5.3 have been foundational for the development of cognitive linguistics as discipline. Taken together with other complementary work within cognitive linguistics [Geeraerts, 2010], this body of knowledge provides a thorough explanation of structuring and functioning of human thought, knowledge and language. It embraces both

⁸Not only that concepts that are firmly entrenched are used automatically, effortlessly and unconsciously, but some of most deeply entrenched concepts tend to become grammaticalized within language, adding another (also less obvious) level of influence on structuring conceptualisations.

functional and cognitive orientation on language (Section 3.2): it approaches the study of language from the perspective of *what it is for*, while building upon the advances of cognitive science to further the understanding of human thought, categorisation and language organisation.

The main insight gained from cognitive-linguistic perspective on conceptual knowledge and natural language lies in approaching natural language by emphasising categorisation as a central function of language, and semantics as a primary linguistic phenomena. The cognitive-linguistic body of knowledge, used in the thesis primarily through cognitive model theory [Lakoff, 1987], portrays conceptual systems as nothing more than the repository of different perspectives on the ‘world’. They reflect the essence of idealised cases experienced in the considered world, as framed against certain background assumptions, and thus embodying a specific conceptual structure on the domain of experience. The inherent coherence of conceptual delimitation of a particular domain of experience is due to the gestalt characteristics of idealised cognitive models, upon which conceptual systems organise.

The emergence, structuring and elaboration of conceptual systems are studied as being motivated by and reflecting the functioning of human cognitive apparatus (*bodily dimension of embodiment*) whose overarching principle is that of cognitive economy. Thus, this principle pervades the structuring and acquisition of conceptual knowledge and language. In turn, these conceptual systems arise and evolve based on the needs and interests of the relevant speech communities. Which perspectives on the ‘world’ are reflected conceptually, at which level of detail and level of elaboration of the conceptual structures, depends on their communicative usefulness within corresponding speech communities (*experiential dimension of embodiment*).

Conceptual knowledge is seen as encyclopaedic in nature rather than monolithic: language stores a variety of conceptual systems within the alike domains of experience, which are alternative to each other and can even be mutually inconsistent. Furthermore, natural languages systematically offer different ways to conceptually frame virtually the same domain of experience, therefore testifying human capacity to conceptualise experiences from various perspectives. The cognitive status (i.e. the status in human mind) of concepts and conceptual systems is intimately linked to their capacity to be employed in human conceptualisation. Not just any conceptual system has this capacity, but their functionally embodiment (such as shaped in the use) is important for their effortless, spontaneous and automatic activation in conceptualisation processes. The concepts/conceptual systems not having this cognitive status require much more effort to be used as mediators of conceptualisation. Nonetheless, it does not mean that humans are not able to acquire new knowledge and refine existing ‘dominant’ (i.e. functionally embodied and salient) ways of thinking in various domains of experience. Indeed, both conceptual systems embodied by individuals, as well as those ‘conventionalised’ in speech communities, are highly dynamic. They evolve with experiences within communities: over time, new structures emerge and old cease to be used based on their relative communicative usefulness for framing new experiences within respective speech communities.

Additionally, in conceptualisation, conceptual systems have the intermediary or mediating role, in the sense that they allow for a certain pre-structuring in the processing of our experiences in the world, while also prompting for further elaboration within context. Indeed, the conceptual knowledge stored in language is always of idealised character (Section 5.2.3), and never covers the richness of possible real-life situations. This ‘filling in’ of other relevant aspects/details often triggers different conceptual elaborations in the use of existing concepts. Some of these, if proven as communicatively useful for individual and communities, over time may become part of individuals and speech communities’ language repertoire.

The exposed cognitive-linguistic explanation of conceptual knowledge, language and phenomena involved in conceptualisation contrasts a deeply engrained assumption, within conceptual modelling field, that there is only one ‘valid’ way of conceptualising a domain of experience, and therefore only one ‘valid’ and ‘complete’ conceptual system pertaining to this domain of experience. In contrast, the cognitive-linguistic perspective enables to study linguistic structure, its different variations and different cognitive status in relation to experiences of different speech communities. This altogether affects the capacity of linguistic structure to mediate human thought, especially in the case of an ‘externally’ introduced linguistic structure.

These two main cornerstones are our primary motivation for using cognitive-linguistic perspective in understanding the role and use of conceptual modelling languages. How this cognitive-linguistic lens is applied is the subject of the following chapter.

CHAPTER 6

A Fundamental View on the Role of Conceptual Modelling Languages

In this chapter, we develop a proposition of a fundamental view on the role of conceptual modelling languages, based on the grounding in selected cognitive-linguistic body of knowledge (Chapter 5). Firstly, we discuss methodological (Section 6.1) and terminological considerations (Section 6.2) relative to our proposition. Thereafter, we justify our contribution through a critical discussion of two principal perspectives from which conceptual modelling languages have been considered in the literature (Section 6.3). Finally, our proposition is developed throughout Sections 6.4– 6.6.

6.1 Method

The present chapter focuses on answering *RQ 2* and, partially, also *RQ 3*, namely:

***RQ 2.** What is the role of a modelling language in conceptual and enterprise modelling?*

***RQ 3.** What are the factors that affect the use of enterprise modelling languages?*

The fundamental view on the role of conceptual modelling languages, developed in Sections 6.4– 6.6, relies on the conceptual and terminological grounds set by the view on modelling discussed in Chapter 4. As illustrated in Figure 6.1, our proposition relies on the critique of current perspectives adopted in modelling language studies (*consensus theory of truth*), and draws on grounding in cognitive linguistics, functional linguistics and cognitive science, exposed in

Chapter 5 (*coherence theory of truth*). The main contribution of our proposition lies in that it offers a theoretical lens on the role of a conceptual modelling language, which opens for a new understanding of the phenomena occurring in language use (as will be demonstrated in Chapter 7).

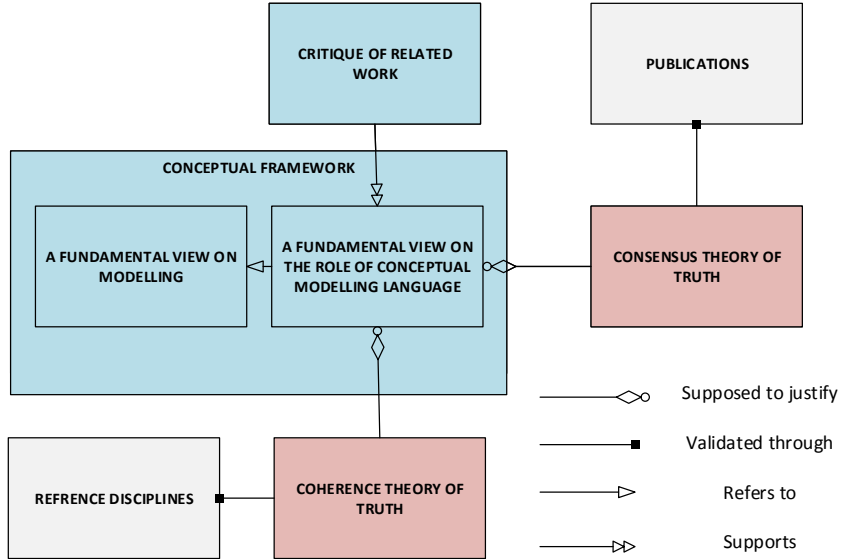


Figure 6.1: A fundamental view on the role of conceptual modelling language: method aspects.

6.2 Conceptual and Enterprise Models

The proposition discussed in the present chapter relies on the conceptual and terminological grounds of the fundamental view on modelling (Chapter 4). However, compared to a general model notion, the specificity of conceptual and enterprise models lies in that the model-artefact is meant to represent (abstract) understanding of the conceptualised domain, thereby typically being structured in terms of entities (i.e. conceptual categories), their properties and relationships.

Conceptual models are widely used in information system and software development, and in enterprise modelling. According to [Wyssusek, 2006], the use of *conceptual models* emerged out of the need to: 1) represent an information processing problem at the level of abstraction that is comprehensible to all parties involved in creation and use of these representations, and 2) independent from the eventual technical realisation of such representations. These drivers emerged more or less in parallel across the disciplines of artificial intelligence, database development, system analysis and programming and human-computer interaction [Wyssusek, 2006].

We consider that **conceptual model** is a model which represents a conceptual understanding (i.e. conceptualisation) of some domain for a particular purpose. In contrast to [Frank, 2011b], who assumes that every conceptual model will be used to bridge the gap between users' domain of discourse and software implementations, we consider that this usage is not inherent to every conceptual model, but is one class of purposes for which conceptual models may be created.

Since conceptual models are about conceptual knowledge, they necessarily rely on concepts. In that sense, conceptual models are linguistic artefacts. While, generally speaking, a conceptual model may be created using not necessarily fully a priori specified language¹, in the discussions in this thesis, we limit ourselves to considering predefined *modelling languages*, such as traditionally known and used in conceptual and enterprise modelling.

Enterprise model is a conceptual model whereby the domain represented is some part of an enterprise. In this context, the term enterprise can refer to the single organisation, networked organisation, or some parts of it. Compared to conceptual models used in e.g. database and software development, enterprise models are bound to specific challenges. Namely, the domain these models deal with is itself a social construction (in which IT/IS may have more or less prominent role), therefore the question of from which perspective to approach the domain, and what is relevant to consider in it, are all subject to social negotiation and consensus Falkenberg et al. [1998], Wyssusek et al. [2001a,b]. Next to that, models as such are mainly used to promote a better understanding of an enterprise, as well as to enhance collaboration, communication and enterprise transformation. Therefore, it becomes critical that models properly linguistically accommodate specific enterprise aspects and context.

6.3 Perspectives on Conceptual Modelling Language: Critique

The *use of modelling languages* is an emergent research topic, which mainly surfaces in empirical studies on conceptual modelling practice [Anaby-Tavor et al., 2010, Davies et al., 2006, Kort and Gordjin, 2008, Malavolta et al., 2013, Recker, 2010, Sandkuhl and Lillehagen, 2008, zur Muehlen and Recker, 2008], and rarely in a more theoretical work [Eriksson et al., 2013, van der Linden, 2015].

From the theoretical point of view, the topics of use and role of modelling language are inextricably related. Depending on how the *role of modelling language* is conceived of from the theoretical point of view, the topic of *modelling language use* is differently treated in the research. In particular, the design decisions regarding conceptual foundation of the modelling language are considered

¹Relaxing the traditional notion of modelling language to include emergent languages and/or cater for language evolution, adaptation and restructuring is interesting in the context of flexible modelling infrastructures, see e.g. [Ossher et al., 2009, Zarwin et al., 2014], where linguistic structure underlying a conceptual model may also be gradually inferred as the model is being created, rather than being necessarily a priori set.

as crucial decisions in language engineering, e.g. [Falkenberg et al., 1998, Frank, 2013, 2014b, Hoppenbrouwers et al., 2005b, Proper et al., 2005, Wyssusek, 2006]. However, the basis and criteria for these decisions are differently considered, depending on the theoretical orientation on conceptual/enterprise modelling language.

In the following, we portray two main theoretical orientations on conceptual/enterprise modelling languages, and discuss their respective considerations regarding the role and use of modelling languages.

6.3.1 Traditional Normative Perspective

Traditionally, a modelling language is conceived as the *representation system* of a *normative character*, which sets the grammar (elements and rules of their combination) to be used in creating representations [Harel and Rumpe, 2004, Karagiannis and Höfferer, 2006].

This perspective on modelling languages is inspired and informed by formal language studies within analytic philosophy and linguistics (Section 3.2). Therefore, it has a rather *structural* focus on modelling language, i.e. it is interested in syntactic-semantic code of a modelling language in an isolated manner, disregarding the interaction with usage contexts, and the variety of users and purposes for which models may be created. Therefore, syntax is concerned with specifying language symbols and rules of their combination, while semantics is typically considered as defining the mapping between syntactic symbols and the semantic domain.

The main focus in normative studies of modelling languages is rather *structural*, i.e. it is focussed on developing representational systems that enable mechanical manipulation of models, and allow the wide reuse of representation systems (and related manipulations) across different scenarios. This requires a fixed and well-defined representation system, thus language specification is, from the normative perspective, concerned with qualities such as non-ambiguity, precision, formality, etc [Harel and Rumpe, 2004, Wand and Weber, 1995]. While in numerous language specifications, semantics is given in natural language format, the ideal for mechanical manipulations is considered a formal semantics definition.

Within the boundaries of normative orientation, *use of modelling languages* is considered rather irrelevant for the research, as it is simply subject to a good training of prospective language users. Hence, any problems related to the use of modelling languages are not only disregarded, but considered as undesirable, even at times connoted as inadequate use or abuse of the specified language. In the period of proliferation of myriad of alike modelling techniques, this connotation has been particularly prominent [Oei and Falkenberg, 1994, Wyssusek, 2006], and ensuring ontological foundations for conceptual modelling [Wand and Weber, 1995] was forwarded as *the* solution to provide a grounding/justification for introducing modelling language constructs and avoid the undesirable variety of modelling notations and (identical claim has been forwarded within enterprise modelling to motivate the UEMML initiative [Opdahl, 2011, Vernadat, 2002]).

However, normative and formal orientation clearly reflects a language conception in which syntax and semantics are treated as completely distinct phenomena [Harel and Rumpe, 2004], and thus, the influence of natural language ‘labels’ (in abstract syntax) on meaning and conceptualisation disregarded. While this conception is useful for an isolated study of syntactic-semantic code, it is not adequate nor tenable if we aim to specifically study the use of modelling languages in relation to the socio-pragmatic context of conceptual and enterprise modelling [Bjeković et al., 2014a, Frank, 2014b, Wyssusek, 2004]. Namely, in the realm of human use, the functioning of concepts is not purely dependent on explicitness, precision and formality of its semantic definitions (machine language paradigm). Just because of the latter qualities, explicitly defined (and formally) grounded concepts do not on their own increase the clarity and efficiency of communication [Hoppenbrouwers, 2003, Wyssusek et al., 2001a], nor do they automatically ensure the adequate/appropriate conceptualisation of the domain of interest [Wyssusek, 2004]. A more recent literature points at many other factors as relevant for understanding and use of modelling languages, such as symbolic socio-cultural contexts of enterprises [Bjeković et al., 2014a, Thalheim, 2012, Wyssusek, 2004], expertise and experience of modellers [van der Linden, 2015], etc. These considerations go beyond formal conception of modelling language. In contrast, formal semantics limits the concepts to purely referential aspects, leaving aside the connection to contexts, observers and domains of modelling, i.e. all context-dependent aspects of meaning².

More fundamentally, even if only implicitly, the normative perspective reflects a positivist orientation on the phenomena of conceptual knowledge and language [Falkenberg et al., 1998, Wyssusek et al., 2001a], as it requires that entities of the (objectively existing) real-world can be identified and ‘mapped’ to concepts independently of human mind and context. However, both conceptual modelling and enterprise modelling are not limited to enabling mechanical model manipulations of representations, but intend to support knowledge creation and sharing [Wyssusek et al., 2001c] within a particular organisational context. Additionally, enterprise modelling also ambitions to enhance communication, collaboration and change within an enterprise [Bubenko et al., 2010, Frank, 2014b]. In such a context, purely normative (and formal) orientation is no longer tenable, as it denies the principles of socio-cognitive functioning of languages and inter-subjective nature of human conceptual knowledge [von Braun et al., 1999, Wyssusek, 2004, Wyssusek et al., 2001a]. Therefore, we consider that broadening the scope of conceptual/enterprise modelling language studies beyond such an orientation is necessary.

6.3.2 Communication Perspective

Within conceptual modelling and IS, language-action perspective (LAP) [Lyytinen, 1984] on IS is one of the influential criticisms of techno-centric conception

²All the context-dependent aspects of meaning are referred to with different terms in the modelling literature, e.g. functional aspects in [Thalheim, 2012], or intentional semantics [Frank, 2014b]

of IS, and consequently conceptual modelling. This perspective stresses that the main purpose of IS is to support coordination and collaborative action in organisations. In this context, IS is regarded as primarily means of human communication, only technically implemented [Lyytinen, 1985]. Consequently, LAP-oriented study of IS is informed by studies of language in its role of enabling communication and social action [Lyytinen, 2004, Weigand, 2005]. On these grounds, various alternative methods for IS development and computer-supported collaborative work (See e.g. [Lyytinen, 2004, Weigand, 2005] for a brief overview), as well as conceptual modelling [Agerfalk and Eriksson, 2002, Eriksson et al., 2013, Falkenberg et al., 1998] were developed as an alternative to the predominant rationalist approaches. In parallel, it also inspired alternative theoretical orientations to conceptual modelling language studies [Falkenberg et al., 1998, Lyytinen, 1985].

In essence, LAP-inspired approaches to conceptual modelling languages emphasise its *instrumental role* and stress the need to take into account various aspects of *modelling pragmatics* [Thalheim, 2012] in theoretical language studies and language engineering. This, for instance, regards the consideration of modelling goals [Hoppenbrouwers et al., 2005a, Krogstie, 2012, Proper et al., 2005], organisational symbolic context [Frank, 2014b, Kaschek, 2013], knowledge of language and experience of stakeholders [Hoppenbrouwers and Wilmont, 2010, Krogstie, 2012], required competencies of participants [Frederiks and van der Weide, 2006], norms governing the organisation and communication [Stamper et al., 2000], the nature of modelling task [Hoppenbrouwers et al., 2005a,c], etc.

Regarding the role of modelling language in particular, Hoppenbrouwers et al. [2005a,b], Proper et al. [2005] forward the *communicative role of conceptual modelling language*: they regard modelling as a communication-driven knowledge transformation process and take the stance that the primary purpose of a modelling languages is to provide means of communication in this process. Likewise, Hoppenbrouwers et al. [2005a], Proper et al. [2005] propose utility as the main dimension of assessing the value of a modelling language with respect to different communicative contexts, and different layers of communication (syntax, semantic, pragmatics) required in the given modelling task. This perspective on modelling language is suggested as promising to promote a better understanding of requirements regarding the design of modelling languages, as well as an alternative perspective to understand the so-called “methodology jungle” [Hoppenbrouwers et al., 2005a].

Similarly, Frank [2011b, 2014b] stresses that conceptual foundation of modelling languages should correspond to the spoken language within the target domain of discourse, to better accommodate for cognitive perspectives of stakeholders, and corresponding symbolic organisational context.

6.3.3 Summary and Motivation

While in line with constructivist stance, the communication perspective on the role and use of modelling languages is more concerned with rules, contexts,

norms and layers of communication³. Although insightful with this regards, it does not sufficiently cater for the fact that a key element in a modelling process consist in *acquisition and mediation of knowledge* [Wyssusek et al., 2001c, p. 17] with a given ‘knowledge exploitation’ goal in mind (enabling some model usage by its intended audience). Communication angle misses to take into account the conceptual content being carried by the language, as well as the interaction of this content with the context and goals of a given modelling effort.

On the other side, normative studies inherit the separation of syntax and grammar from the formal language studies, and disregard the fact that the abstract syntax not only sets the symbols and rules of their combination, but as well defines the *conceptual foundation* of a language. How concepts affect the conceptualisation, and what are the conditions for their successful signification is not paid too much attention to from this perspective. Concepts, conceptual knowledge and language are approached from the positivist stance, at best assuming that concepts should and will be used in line with the stipulated language definition.

Finally, neither of the two prevalent theoretical orientations studies the nature of human conceptual knowledge, its organisation and functioning in relation to conceptualisation processes. This motivates our proposition. In our research, we put forward *conceptual knowledge* dimension as crucial in the study of conceptual modelling language. This orientation is inspired by [Falkenberg et al., 1998, Frank, 2011a, Wyssusek, 2004, Wyssusek et al., 2001c], and shares the view of [Falkenberg et al., 1998, Frank, 2011a] that conceptual foundation of the modelling language is its crucial element, on which all other elements of modelling language depend. Consequently, in our thesis, the role of conceptual modelling language is studied relying on a fundamental understanding of the relationship between knowledge, language and conceptualisation, as elaborated in Chapter 5.

6.4 Twofold Function of Conceptual Modelling Language: A Proposition

Our proposition of a fundamental view of the role of conceptual modelling language is built on two main cornerstones. Firstly, we propose that a deeper insight into nature, use and design of a conceptual modelling language can be gained by studying structure and functioning of conceptual knowledge/conceptual systems in natural languages in line with cognitive-linguistic orientation (Chapter 5). Secondly, in line with the former, as well as with (functionally-oriented studies approaches to language in general and) communication perspective on modelling languages in particular, we explicitly adopt the utility orientation on conceptual modelling languages. Consequently, our proposition can well complement functionally-oriented studies of conceptual

³This claim to some extent parallels the critique of LAP-inspired approaches to conceptual modelling, e.g. [Agerfalk and Eriksson, 2002, Eriksson et al., 2013]

modelling languages.

Utility orientation. We consider conceptual/enterprise modelling language as *means to and end*, in other words, as instrumental to creation of a purposeful model. Consequently, the cost-effective use of a conceptual modelling language should be possible.

The notion of **cost-effectiveness**, here inspired by [Proper et al., 2005, Rothenberg, 1989], puts forward a pragmatically oriented trade-off between costs/effort involved in adopting and using modelling language and the benefit/value obtained from the invested effort. As a consequence, the cost-effectiveness as a central notion goes beyond a narrow focus only on effort minimisation in language use (reflected in considerations around *ease of use*, *ease of learning* or *understandability* of a modelling language). Instead, the notion of cost-effectiveness ties the judgements related to language use to the trade-off between cost and benefit obtained from the language within a particular modelling effort. This leaves open the possibility that, at times, an increased effort involved in using the language may potentially be justified or justifiable by the value obtained.

Next to that, the utility and cost-effectiveness such as adopted here come with the assumption that the value of modelling language is inherently related to its use: namely, the effort invested in and value of a modelling language depends on the particular modelling context and its goals, and thus cannot be fully determined a priori.

To discuss our proposition, we first characterise a conceptual/enterprise modelling effort $\langle mc, O, p, ML \rangle$ in terms of (at least) the following elements:

- Modelling context **mc**, given by the wider context to which the conceptual modelling effort pertains (typically situated in relation to an information system or an enterprise),
- Observer **O**, i.e. the participants of the modelling effort who are either model creators or intended audience of the model,
- Purpose **p** of the model, as well as
- Modelling language **ML**, selected for the modelling effort. Typically, the **ML** to be used is an engineered and/or standardised modelling language.

We propose that *when used* in a conceptual/enterprise modelling effort $\langle mc, O, p, ML \rangle$, a conceptual modelling language has two interrelated functions, which correspond to two main streams of modelling, as illustrated in Figure 6.3, namely:

- **Linguistic function** - The modelling language is aimed to facilitate framing of the discourse about a domain and shaping the observer's domain conceptualisation. In its linguistic function, it is thus intended to facilitate conceptualisation stream of modelling (Figure 6.3).

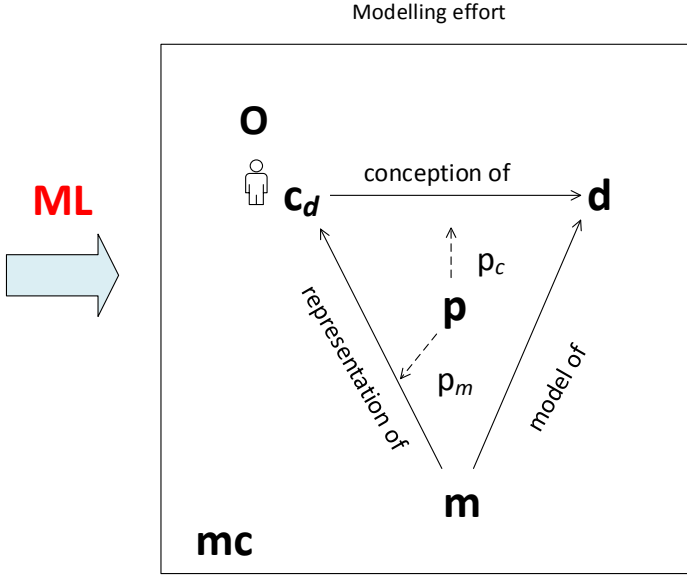


Figure 6.2: Conceptual/enterprise modelling effort: $\langle mc, O, p, ML \rangle$

- **Representational function** - The modelling language is aimed to also facilitate the creation of a purposeful model, i.e. to facilitate manifestation stream of modelling (Figure 6.3).

In the following, we first discuss the proposed understanding of linguistic function (Section 6.5), and expose also some considerations in relation to the representational function (Section 6.6) of conceptual modelling language. In doing so, our focus is clearly on the linguistic function, namely on the principles of its structuring and functioning. The implications relating to the representational function are only drawn partially, having in mind that this function is far more studied in conceptual modelling research.

6.5 Linguistic Function

In its linguistic function, conceptual modelling language **ML** is meant to *mediate* the conceptualisation stream of conceptual/enterprise modelling. To this end, the modelling language provides a specific classification of concepts (conceptual foundation of the modelling language), i.e. a specific linguistic structure, **ML_{LS}**.

To better understand **ML_{LS}** in its linguistic function, we propose to consider this linguistic structure as essentially subject to principles of structuring and functioning of just any conceptual system in natural languages. We claim that the cognitive-linguistic understanding of how conceptual systems are motivated, how they arise, are organised and how they function in natural languages can provide valuable insights into how and why conceptual modelling languages are

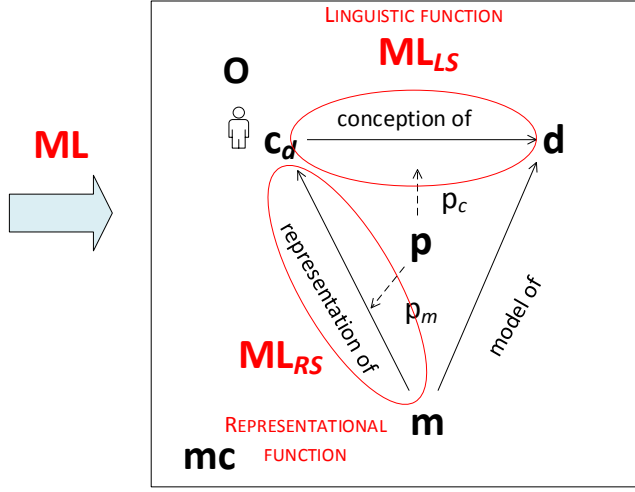


Figure 6.3: A twofold function of conceptual modelling language

used. In adopting this perspective, we bear in mind that \mathbf{ML}_{LS} of an engineered modelling language is to some extent ‘artificially’ designed: unlike typical conceptual structures in natural languages which are fully motivated by, rooted in and organised according to the pragmatic communication and knowledge sharing needs, engineered conceptual structures may be biased by different techno-economical drivers (e.g. standardisation, optimisation, harmonisation, productivity, etc.) [Bjeković et al., 2014b], as well as by the individual designers preferences (e.g. technical experts, engineering-oriented profiles, etc.) [Frank, 1998].

Nevertheless, language engineering and particularly standardisation is at least to some extent still motivated by the existing human practices and general patterns of communicating and acting in a domain of interest, and driven by the ambition to improve these. Indeed, very often some kind of ‘reference knowledge’ is incorporated into language definition. While drawing a full parallel between the conceptual systems in natural language and in modelling languages is not possible, we can still consider that the core principles of knowledge structuring (See Chapter 5) are applicable to the analysis of modelling languages. For instance, it can help identify the problems and challenges in the use of modelling language related to specific features or specific structure, and offer the foundation for analysing and reflecting on different design choices for \mathbf{ML}_{LS} . In this light, the fact that different techno-economical drivers present in language engineering often are overemphasised and result in hindering the clear rationale behind a conceptual structure of \mathbf{ML}_{LS} further motivates our proposition. Finally, we certainly consider that the use of \mathbf{ML}_{LS} by humans in conceptualisation is subject to such principles. In

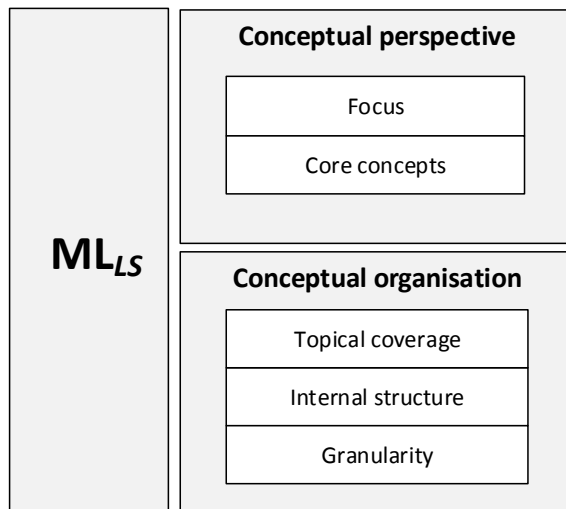


Figure 6.4: Conceptual perspective and conceptual organisation: key dimensions of \mathbf{ML}_{LS}

other words, regardless of how \mathbf{ML}_{LS} is defined, it is used by humans according to the same principles of usage of human concepts in natural languages.

In the present section, and based on the insights from selected reference disciplines (Chapter 5), we define the essential characteristics for analysing the “knowledge structure” within \mathbf{ML}_{LS} (Section 6.5.1). After that, we identify and discuss the main elements for understanding the use of \mathbf{ML}_{LS} in conceptualisation processes of conceptual/enterprise modelling (Section 6.5.4).

6.5.1 Understanding Linguistic Structure \mathbf{ML}_{LS}

Cognitive model theory [Lakoff, 1987] proposes the notion of ICM (Section 5.2.3) as an atomic unit of analysis of any conceptual organisation, and as particularly relevant for the study of categorisation function of language. This theory demonstrates that conceptual systems in language are organised according to an inherent logics of characterising or elaborating an idealised case, which lies at the core of a category. Furthermore, it also demonstrates that this underlying logics of conceptual organisation is crucial for semantic analysis and for understanding the use of individual concepts. According to Lakoff [1987], this underlying coherence of a conceptual system constitutes the basis for understanding the meaning of all individual concepts within a particular category structure (as illustrated by means of several examples in Section 5.2.3).

Using the essential characteristics of ICMs (Section 5.2), we propose a framework for analysis of \mathbf{ML}_{LS} . This analytic framework seeks to analyse the *underlying pragmatics of a certain linguistic structure*, using the following dimensions, as illustrated in Figure 6.4:

- **Conceptual perspective** refers to the perspective from which a domain of interest is conceptualised and captures in the conceptual structure. This is always tied to some background assumptions and frames of knowledge called upon when approaching the domain of interest. As Lakoff [1987] suggests, these assumptions are subsequently reflected in understanding the meaning of concepts and the very structuring of conceptual systems. We propose to further characterise the conceptual perspective in terms of:
 - **Focus** which basically reflects the point of focus (See also [Hoppenbrouwers and Wilmont, 2010]), the focal point of conceptualisation, as reflected in \mathbf{ML}_{LS} ⁴,
 - **Core concepts**, which reflect the central elements of the perspective, and are the centre of all the conceptual elaborations in \mathbf{ML}_{LS} , e.g. exceptions, specific cases, etc.
- **Conceptual organisation** is evidently inherently related to the perspective taken, and reflects the detailed structuring of conceptual knowledge about the domain of interest considered within \mathbf{ML}_{LS} . We propose to analyse it in terms of the following dimensions:
 - **Topical coverage** meaning the ‘aspects’ of a domain of interest covered in \mathbf{ML}_{LS} (thereby defining its boundary),
 - **Internal structure** of \mathbf{ML}_{LS} which, besides *concepts and their relational structure*, can also include elaborate frameworks (e.g. defining aspects and layers, as organising elements for the entire conceptual structure in ArchiMate language [Lankhorst et al., 2010]).
 - **Granularity**, meaning the level of detail in the elaboration of concepts, properties and relationships. Typically, the level of details found in the definition of \mathbf{ML}_{LS} is related to the perspective taken on the domain of interest.

The proposed analytic framework obviously is orthogonal to the traditional distinction of syntax and semantics in conceptual modelling language design (Section 3.3.1). While the traditional distinction is focussed on the properties of the linguistic code, the framework proposed hereby seeks to analyse the inherent logics, i.e. pragmatics, underlying the conceptual structure. In that sense, it can be said that the *conceptual perspective* of \mathbf{ML}_{LS} intends to characterise the essence of how a given domain of interest is delimited, capturing what lies at the basic-level experience in the given domain of interest (Section 5.2). This, in our view, may correspond to an *idealised* case of a domain of interest, similar to Lakoff [1987]’s views on ICM. On the other hand, the *conceptual organisation* dimension characterises detailed conceptual structuring of the domain of interest

⁴The notion of focus can also be related to the notion of *principle of dominant decomposition*, by which the early IS methods and modelling approaches were distinguished, e.g. process-oriented decomposition of IS, versus function-oriented approaches such as structured system analysis. This means that the ‘system’ is being approached from the perspective and having the focus on *process* or *function*, respectively.

in terms of the topics covered, and levels of details adopted, based on the frames of knowledge brought forward. Therefore, the differences in detailed conceptual organisations across different \mathbf{ML}_{LS} (of the same domain of interest, e.g. process) may be characterised and explained in relation to the topics, and frames of knowledge brought about in the particular conceptualisation of the domain. In addition, the framework proposed appreciates that a modelling language, namely \mathbf{ML}_{LS} , typically entails ways to *conceptually manage the complexity of a domain of interest*, often referred to as ‘way of thinking’ in the literature. From our point of view, this is an integral part of the analysis of \mathbf{ML}_{LS} , as it actually provides the pragmatic rationale for the entire conceptual structuring within \mathbf{ML}_{LS} .

Additionally, based on the cognitive model theory’s emphasis on an underlying logics and coherence of a conceptual organisation, offers a complementary perspective on understanding semantics of modelling languages. Namely, instead of just the quality of individual construct definitions or just the ‘labels’ used for concepts of \mathbf{ML}_{LS} , the conceptual organisation as a whole, as well as its underlying pragmatics, have an important impact on the understanding individual concepts of \mathbf{ML}_{LS} .

6.5.2 Illustration of the Analytic Framework on BPMN

To illustrate how the proposed analytic framework can be used in the analysis of the linguistic structure of a modelling language, we will use the case of BPMN 2.0 specification. We study the BPMN specification, and its practical use, as presented in [Recker, 2010, zur Muehlen and Recker, 2008].

Conceptual perspective. The design of BPMN as a modelling language (and later standard) was motivated by the need for process modelling notation that is readily understandable “by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes” [OMG, 2011, p.31]. Therefore, the *Business Process* is a central element around which the conceptual perspective is shaped.

- **Core concepts** – One would then expect *Business Process* concept to be explicitly present in the language specification as well, but interestingly enough this is not the case. The standard specification provides the following list of the core concepts of BPMN (i.e. Basic BPMN Modelling Elements [OMG, 2011, p. 28]): *Event, Activity, Gateway, Sequence Flow, Message Flow, Association, Pool, Lane, Data Object, Message, Group (a box around the objects within the same category, Text Annotation)*. On the other hand, according to the insights into practical use of BPMN [Recker, 2010, zur Muehlen and Recker, 2008], the core concepts seem to rather be *Activity, Flow, Start Event* and *End Event*, as well as *Pool*, and *Data-based XOR*. Therefore, the practically used core concepts set tends to be

simpler and more coherently oriented on a simple process documentation class of purposes [Recker, 2010].

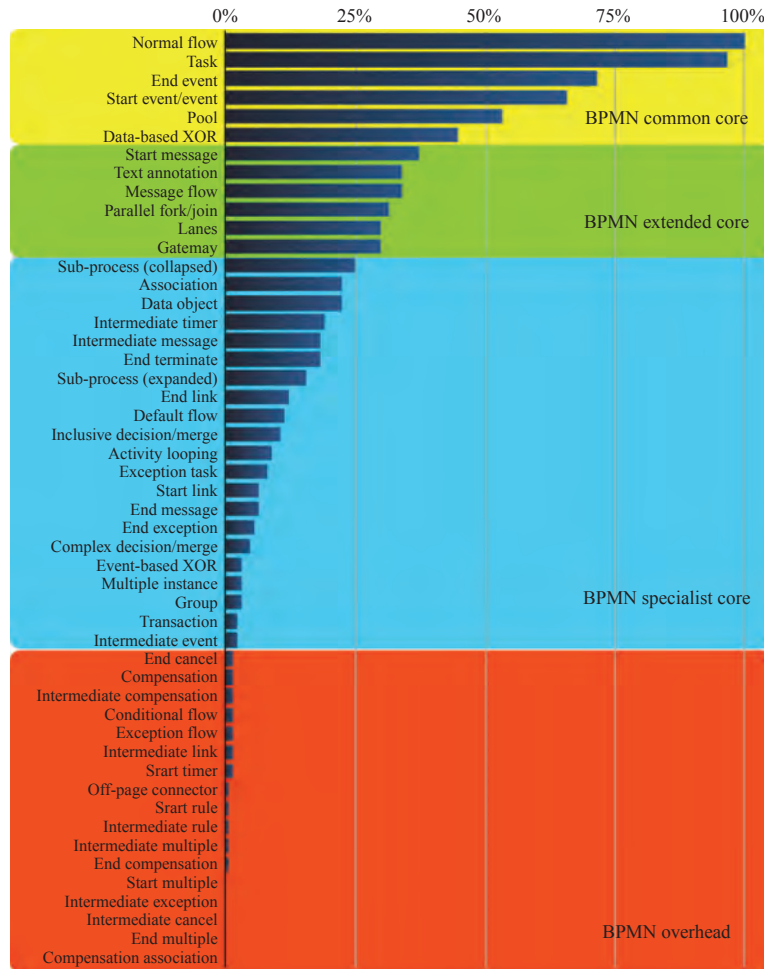


Figure 6.5: The frequency of use of BPMN constructs and suggested grouping of concepts, taken from [Recker, 2010, p. 193]

- **Focus** – On paper, the focus of BPMN specification is modelling processes for business users primarily, and also on creating the bridge between business view (e.g. business process design) and technical view (e.g. process implementation) on processes. Therefore, the conceptual perspective taken on process modelling in BPMN is intended to ‘integrate’ both business view and technical view on business processes. However, the closer analysis of the standard specification reveals a language rather geared towards advanced and rarely used technical purposes of process modelling

(See Figure 6.5). Furthermore, in defining the scope of the modelling language, the standard document states that BPMN is constrained to only cover concepts relevant to business process modelling, leaving aside other kinds of modelling for business purposes in organisation.

Therefore, although intended to allow for business process modelling of different kinds (e.g. private and public processes, choreography, collaboration, conversation), the practical insight reveals that the perspective taken on process modelling is not necessarily adapted to what is usually done with process modelling in practice. “This situation points to BPMN being a pure process modeling language. Users, however, often are concerned with enterprise modeling [...] beyond the mere depiction of the control flow of their business operations” [Recker, 2010, p. 189]. It can be said that the focus of a standard is indeed rather on the detailed flow and control of process execution, therefore too narrow for its stated purpose.

Conceptual organisation. The BPMN v2.0 standard offers around 50 different constructs which are organised in terms of core and extended set. The core set is reflecting the core construct categories of Flow Objects, Data, Connecting Objects, Swimlanes, Artifacts, while the extended set is supposed to provide different refinements of these basic BPMN elements. The practical insights report that the very big number of these constructs is not frequently, if at all, used in practice (See Figure 6.5 and 6.6).

- **Internal structure and topical coverage** – In defining the scope of the modelling language, the standard document states that BPMN is constrained to only cover concepts relevant to business process modelling, leaving aside other kinds of modelling for business purposes in organisation. Consequently, the standard document explicitly states to leave aside definition of organisational models and resources, functional modelling, data and information models, strategy modelling and business rules modelling, suggesting that these belongs to other models which should be integrated with process models. However, BPMN is in practice mainly used for process documentation and improvement, knowledge management, organisational redesign. For these topics (classes of purposes), a very small subset of essential BPMN constructs is needed (See Figure 6.6). Besides these core concepts, practitioners report that they lack constructs for expressing business rules, organisational resources and roles (*Pool* and *Lane* are reported as vague and not appropriate [Recker, 2010, Wohed et al., 2006]), risks, performance, etc. This corroborates the pattern of ad-hoc extension of BPMN models observed in [Recker, 2010]: the BPMN models are very often extended with the symbols allowing to capture organisational information, such as data, risks, resources, documents etc. This indicates that the standard targets too broad a range of purposes of process modelling. Furthermore, the standard is reported not to accommodate well the needs of its business audience: it does not come with relevant constructs for modelling processes from the business perspective [Recker, 2010].
-

- **Granularity** – Overall, the BPMN specification contains a great deal of detail in modelling process flow control: it has an extensive number of differentiated Event and Gateway constructs, and similar variety for modelling different flows between activities. This, in our view, once again confirms that the focus of a standard is more on the control of process flow, rather than enabling business process modelling for business users.

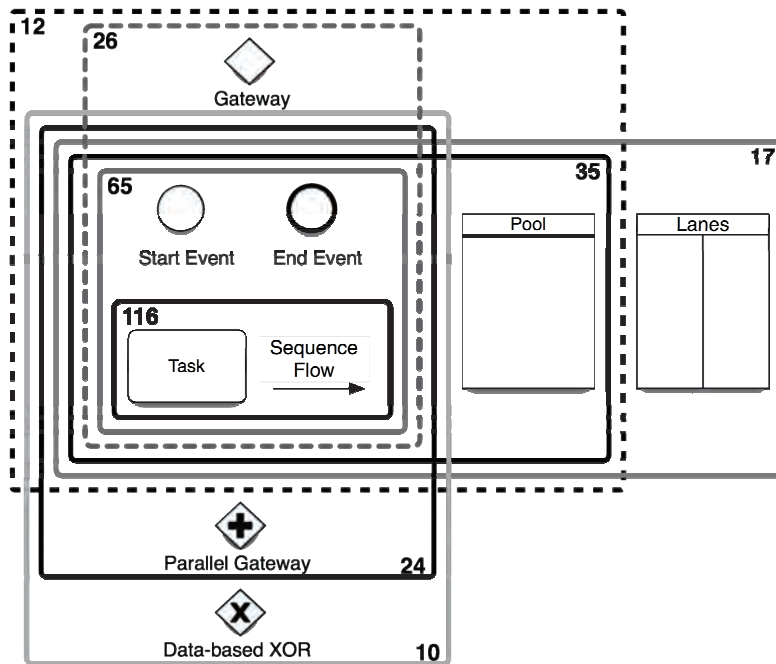


Figure 6.6: Popular BPMN vocabulary subsets [zur Muehlen and Recker, 2008, p. 477]

Interestingly, in their analysis, zur Muehlen and Recker [2008] conclude that BPMN constructs are used in clearly delineated subsets, and suggest “that the frequency of BPMN constructs follows an exponential distribution, both at the elementary level and the subset level. This means that the practical use of a formal modeling language shows similarities to the use of natural language, and suggests that linguistic techniques can be applied to better understand the formation and use of languages in conceptual modeling overall” [zur Muehlen and Recker, 2008, p. 478]. The study of linguistic function in our thesis is indeed developed based on this assumption, as well as the proposed framework for analysis of the linguistic structure underlying modelling language. Illustrating the dimensions of this framework on the BPMN example, we show that such framework of analysis may be useful for identifying and analysing patterns in language use, as well as ‘misalignments’ between the intended language functionality, as stated in standard specification, and its practical needs. The

assumption taken here is that the clarification of underlying pragmatic rationale of conceptual structure can help better understand the gap between designed linguistic structure and its use. In the empirical study, discussed in Chapter 7, we look at the adequacy of these dimensions for understanding and explaining the use of modelling language.

6.5.3 Positioning with Regards to Representational Analysis

The analytic framework proposed in Section 6.5.1, though yet to mature, needs to be positioned with regards to the existing frameworks of modelling language analysis and evaluation, namely the framework of representational analysis [Wand and Weber, 1995]. This discussion is necessary if we consider that the our analytic framework may eventually grow into an alternative evaluation approach.

The representational analysis forwarded by Wand and Weber [1995] has become widely used in evaluation of modelling ‘grammars’. The hypothesis of Wand and Weber [1995] is that a ‘good’ modelling grammar needs to demonstrate the qualities of ontological *completeness* and *clarity*. In this context, the ontologically complete grammar ensures the coverage of (the meaning of) relevant aspects of the real world (as captured by BWB ontology), whereas the ontological clarity ensures one-to-one correspondence between modelling grammar constructs and ontological constructs. According to Wand and Weber [1995], one is bound to creating ambiguous descriptions of real world if one uses the ontological incomplete and unclear modelling grammar, and this should be avoided.

First of all, the analytic framework targeting linguistic structure we proposed in Section 6.5.1 is built on constructivist assumptions. Therefore, we do not adhere to the use of BWB ontology as the *basis for* assessment of clarity and completeness of any conceptual or enterprise modelling language⁵. From the constructivist stance, the evaluation against an “axiomatic ontological system” [Wyssusek, 2004] is simply not very informative [Frank, 2011a, Lyytinen, 2006].

Secondly, we consider that the qualities of clarity and completeness (although not interpreted in the sense of above-mentioned proposition of Wand and Weber [1995]) in modelling language definition are relevant as a guideline in language engineering, but are challenging to operationalise outside of positivist stance. In addition, these categories still do not warranty *per se* the quality of produced models, which can be summarised in the following statement:

- “It is possible to make good models in a poor modelling language.
- It is possible to make poor models in a comparatively good modelling language” [Krogstie, 2006, p. 111].

⁵The extensive debate on the appropriateness of Mario Bunge’s ontology, and in general ontological grounding, as the basis for the evaluation of conceptual modelling languages can be consulted in [Henfridsson et al., 2006]

Namely, from the constructivist point of view, the ‘domain of interest’ is not just *given* in the real world, but is shaped by social practices and existing consensus at a given point of time. Taking this into account, the quality of *completeness of a linguistic structure* is at best some kind of approximation. Next to this, what is relevant – in terms of perspective to take on the considered domain – depends on the specific context and modelling goals. It may change across not only contexts, but also over time⁶. “Instead of assuming like Wand and Weber a single representational system that would map the world (as it is) – another alternative is to examine the representation and the reality as co-constitutive, and assume that alternative linguistic systems (grammars) will organize and constitute our world differently (but still retain some fidelity towards the world outside the representations)” [Lyytinen, 2006, p. 82]. Indeed, this is the approach we take. In this context, the very separation of the dimensions of *conceptual perspective* and *conceptual organisation* introduced is based on the assumption that alternative conceptualisations of similar domains of interest are not only possible but may as well be ‘valid’, even within virtually same domains of interest. This, for instance, may be justified by a different model purpose, or different ways of looking at, i.e. conceptually structuring, similar phenomena within different socio-cultural practices (which indeed is the essence of weak hypothesis of linguistic relativity (See Section 5.3.3). The proposed analytic framework caters for this possibility, and allows to compare these alternative conceptual structures at a finer-grained level, than e.g. the evaluation frameworks currently known in the literature (such as e.g. [Krogstie, 2012, Wand and Weber, 1995]).

Lastly, when it comes to *the clarity of a linguistic structure*, we interpret it as a property of modelling language construct definition. The *definitional clarity* is usually acknowledged as important in the context of language learning and novice modellers. For instance, van der Linden [2015] demonstrates that unlike novice modellers, more experienced modellers are less likely to rely on strict definitions of meta-concepts, and tend to rather understand them as graded categories. Nonetheless, besides definitional clarity of the individual constructs of a language, our proposition underlines the importance of coherence of an entire conceptual structure as an important role in language understanding and acquisition. This however is rarely considered as important in modelling language studies. Although we may be able to position the definitional clarity dimension as an inherent part of the proposed analytic framework (somewhat cross-cutting the distinction of conceptual perspective and conceptual organisation), we refrain from doing so before thorough empirical insight.

⁶“The constructs provided by the BUNGE–WAND–WEBER ontology do not need to be grounded in some metaphysical theory. They might serve us well if we understand them as descriptions or specifications of conceptualizations. If we commit to this ‘ontology’ we commit ourselves to a vocabulary and a grammar that might or might not be useful to be used when we speak about ‘the world’. We will know if we try to express our conceptualizations by means of this ‘ontology’. If it does not serve our purpose we do not have to change our worldview – changing the vocabulary and the grammar will suffice” [Wyssusek, 2004, p. 4306].

6.5.4 Influence of Linguistic Structure \mathbf{ML}_{LS} on Conceptualisation

A conceptual/enterprise modelling language, more precisely its underlying linguistic structure \mathbf{ML}_{LS} , is often designed with the intention to embed some kind of ‘reference’ knowledge or best practices in a certain domain of interest, which – by means of mediating conceptualisation processes – are aimed to be transferred in the given modelling effort and model being created.

In our research, we however do not assume that this influence is automatically materialised, and independent of modelling context, goals and particular observer. Instead, the engineered \mathbf{ML}_{LS} can be regarded as a proposition of the way of thinking, i.e. of a perspective and concepts to structure a certain ‘domain of interest’, whereas its actual use in context can be regarded as a platform of negotiation of value of such proposition. Therefore, the materialisation of intended value of \mathbf{ML}_{LS} entails the process of assessing and negotiating the adequacy of \mathbf{ML}_{LS} for the given $\langle mc, O, p, ML \rangle$.

Forming Conceptualisation

We postulate that in $\langle mc, O, p, ML \rangle$, there is an ongoing process of shaping what we may refer to as *ML-independent conception of domain*. At the same time, \mathbf{ML}_{LS} is meant to superimpose itself over the former, or to redirect it, to form what we refer to as *ML-mediated conception of domain* (See Figure 6.7). In this context, many factors may affect linguistic functioning of \mathbf{ML}_{LS} . While it is complex and nearly impossible to pinpoint at the individual influences, we focus on the most important ones in the following discussion.

\mathbf{ML}_{LS} -independent linguistic framing of the domain. First of all, it is important to acknowledge that the conceptualisation process is affected by the wider socio-pragmatic context [Frank, 2014b, Wyssusek et al., 2001a], as well as individual pre-suppositions of the observer \mathbf{O} [Proper et al., 2005]. In (a conceptual but specifically in an) enterprise modelling setting, the *socio-pragmatic context* of $\langle mc, O, p, ML \rangle$ plays important role in shaping conception of domain in a given modelling effort, through entailing existing patterns of communicating and acting within organisations [Frank, 2014b, Wyssusek et al., 2001a], and thus through existing and entrenched patterns of framing different domains of interest. These are inevitably imported in the process of creating *ML-independent conception of domain* in $\langle mc, O, p, ML \rangle$. Furthermore, based on our propositions in Chapter 4, the purpose \mathbf{p} plays the role in delimiting the relevant aspects of the ‘world’ to take into account when shaping the domain \mathbf{d} . Additionally, specific experience, expertise and professional background of individuals in the role of observer in $\langle mc, O, p, ML \rangle$ also plays a role, as they affect the habitual patterns of thinking and interpreting, reflected in his/her entrenched conceptual structures. To which extent an observer is aware of this bias, and able or willing to leave it aside, is an individual issue and cannot be controlled.

The combined influence of these factors leads to *ML-independent conception of the domain*. i.e. **ML-independent \mathbf{c}_d** as illustrated in Figure 6.7. The

latter may be more or less clear, complete and structured, as well as more or less adequate in the context of $\langle mc, O, p, ML \rangle$. Throughout modelling process, this conception is being refined in relation to the **mc** and **p**. Hence, the linguistic expression of the domain **d** is being refined accordingly. This process is independent from the influence of \mathbf{ML}_{LS} .

\mathbf{ML}_{LS} -mediated conception of the domain. We assume that the linguistic structure of \mathbf{ML}_{LS} is usually not functionally embodied, and by default will not automatically and effortlessly mediate the conceptualisation. Instead, it is a conscious choice to use \mathbf{ML}_{LS} . For it to interfere with *ML-independent conception of domain*, \mathbf{ML}_{LS} is first made sense of with regards to existing conceptual knowledge, and assessed for relevance within to $\langle mc, O, p, ML \rangle$. Relying on the cognitive-linguistic understanding of these processes, we suggest that two factors are relevant for the success of \mathbf{ML}_{LS} in its linguistic function:

- The extent of functional embodiment of linguistic structure \mathbf{ML}_{LS} , and
- Utility of linguistic structure \mathbf{ML}_{LS} within a given $\langle mc, O, p, ML \rangle$.

These factors are identified based on the overarching principles involved in the use of conceptual systems, and more specifically ‘acceptance’ of new linguistic structures into an existing linguistic frame of a speaker and/or speech community. (discussed in Section 5.3), i.e. *cognitive economy* and *communicative usefulness*. While the dimension of embodiment puts more emphasis on the pre-conditions for a \mathbf{ML}_{LS} to at all be able to mediate conceptualisation process, the notion of utility considers the value of \mathbf{ML}_{LS} in regard to the specific modelling effort and context.

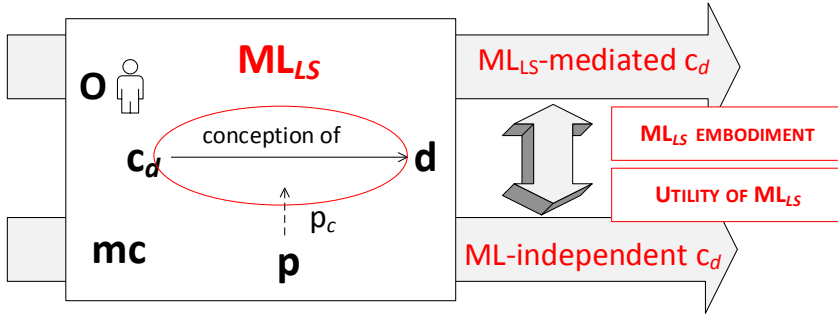


Figure 6.7: Linguistic Function: continuous negotiation.

Functional Embodiment of Linguistic Structure

As discussed in 5.3.3, the functional embodiment of a conceptual system (ICM) is crucial for its capacity to effortlessly mediate conceptualisation.

For our purposes, we discuss the embodiment of \mathbf{ML}_{LS} by an observer **O** in relation to $\langle mc, O, p, ML \rangle$. In most cases, one can expect that \mathbf{ML}_{LS} is

not likely to be fully entrenched and hence effortlessly used by the participants in the observer role **O**. Consequently, the adoption and use of \mathbf{ML}_{LS} as a mediator of conceptualisation will require a conscious cognitive effort by **O**. Some extent of embodiment of alike linguistic structure increases the likelihood that \mathbf{ML}_{LS} will enter the process of conceptualisation without overloading the observer **O**.

If not functionally embodied, \mathbf{ML}_{LS} is made sense of by the comparison of schematic nature⁷ with already functionally embodied conceptual systems, which are also salient in the given (communicative) context. The closer \mathbf{ML}_{LS} as a whole is to already embodied and salient conceptual systems, the less cognitive effort its use will require. This argument can be considered as lying at the heart of the proposition of domain-specific enterprise modelling languages [Frank, 2011b, 2013].

Additionally, the modelling expertise and experience of observer **O**, as well as certain characteristics of \mathbf{ML}_{LS} (e.g. clarity of its conceptual definitions), can also affect cognitive effort required in adopting \mathbf{ML}_{LS} . For instance, a modelling expert in the role of **O**, due to the his/her education, expertise and consistent experience, is expected to already be used to think at the level of abstraction and in a cognitive style typical of modelling languages. For these reasons, the more abstract concepts are more likely to be embodied by expert modellers, who typically have a lot of experience of thinking at a raised level of abstraction [Wilmont et al., 2012, 2013]. While conceptual modelling languages differ between themselves in terms of perspective, core concepts and particular conceptual organisation, they can be considered at residing at close levels of abstraction, which are more or less familiar to an expert modeller. We assume here that, throughout the years of modelling experience, a modeller is exposed to and uses different modelling languages, and is therefore able to grasp any \mathbf{ML}_{LS} , due to the similarity of their cognitive styles. Consequently, we consider that the adoption of \mathbf{ML}_{LS} by an expert modeller is not likely to require significant cognitive effort.

However, for a typical EM stakeholder or novice modeller [Wilmont et al., 2012, 2013], making sense of and adopting \mathbf{ML}_{LS} involves a non-negligible increase in cognitive effort. Indeed, not only that \mathbf{ML}_{LS} is not close to novice modeller's ways of thinking, but the language training alone is not likely to be sufficient to significantly affect the embodiment of \mathbf{ML}_{LS} . Therefore, the use of \mathbf{ML}_{LS} is likely to require greater cognitive effort for a novice modeller and typical EM stakeholder⁸.

In addition, we hypothesise that the crucial aspect for the adoption of \mathbf{ML}_{LS} within $\langle mc, O, p, ML \rangle$ more importantly lies in the understanding of its conceptual perspective. Namely, by understanding the particular adopted

⁷As we have seen in Section 5.3, human mind understands new conceptual structures in terms of already familiar conceptual structures.

⁸Finally, theoretically speaking, even if \mathbf{ML}_{LS} is not sufficiently embodied, it can still be consciously pondered and used to mediate the conceptualisation within a given modelling effort. In that case, its perceived *utility* (Section 6.5.4) should be such that it outweighs the efforts used, therefore implying a positive cost-benefit ratio, i.e. the cost-effective use of \mathbf{ML}_{LS} . This situation is, obviously, more likely to happen when observer **O** is an expert modeller, than in any other case.

perspective, the details of the corresponding conceptual organisation can be understood with less effort, against the background of adopted perspective (as an extension/elaboration around core concepts).

Utility of Linguistic Structure

If \mathbf{ML}_{LS} can be made sense of and/or is internalised to the extent that it can enter the conceptualisation process (even if some of its concepts are consciously pondered within the process), there remains the question of its utility, i.e. *the utility of \mathbf{ML}_{LS}* for $\langle mc, O, p, ML \rangle$, as a result of evaluation of the observer \mathbf{O} and for $\langle mc, O, p, ML \rangle$ ⁹.

It is to be noted that the judgement of utility of \mathbf{ML}_{LS} is a cumulative result rather than one-off decision, and is related to trying out and reflecting on particular framing of the domain \mathbf{d} , in parallel with the gradual alignment of the \mathbf{d} , \mathbf{p} and \mathbf{m} . Strictly speaking, this judgement of utility of \mathbf{ML}_{LS} may also be erroneous, however we assume that, generally speaking, an average observer is intuitively able to choose the adequate pragmatic focus [Hoppenbrouwers and Wilmont, 2010] within the given conceptualisation setting. The explicit and justified evaluation of the utility of \mathbf{ML}_{LS} within $\langle mc, O, p, ML \rangle$ is thus beneficial to alleviate this risk.

The assessment and choice of ‘adequate’ conceptual structuring of the domain \mathbf{d} by the observer \mathbf{O} relates to the utility of a specific *conceptual perspective* and *conceptual organisation* (Section 6.5.1) in \mathbf{ML}_{LS} with respect to $\langle mc, O, p, ML \rangle$. In this context, it may well be that a particular conceptual perspective and/or structuring entailed by \mathbf{ML}_{LS} , though potentially functionally embodied by an observer \mathbf{O} , are not assessed as adequate within a given $\langle mc, O, p, ML \rangle$.

Indeed, while certain \mathbf{ML}_{LS} may well be embodied by an \mathbf{O} , this does not per se imply the utility of \mathbf{ML}_{LS} in any given modelling effort. Our previous cognitive-linguistic discussions (Sections 5.2 and 5.3) suggest that, within some domain of interest, several alternative linguistic framings may exist and be embodied within languages spoken. According to Lakoff [1987], each of such alternative ICMs/conceptual systems within a language reflect their communicative usefulness for different social and pragmatic settings. Consequently, there may exist multiple perspectives interesting/relevant to adopt within a given conceptualisation situation, depending on the intended goals, and focus of considerations within a modelling effort, etc.

For instance, while the design of DSMLs is suggested to draw on the

⁹Note that the concept of utility of \mathbf{ML}_{LS} is closely related to the notion of *pragmatic focus* of conceptualisation [Hoppenbrouwers and Wilmont, 2010], and the proposition of utility-oriented selection of modelling language concepts [Proper et al., 2005]. While congruent with these works, the nuance in our theoretical considerations lies in the following. First of all, compared to [Hoppenbrouwers and Wilmont, 2010], we do not only consider the selection of a modelling language for the given task, but also analyse its use in the given modelling task. With regards to [Proper et al., 2005], we emphasise that the utility of a concept within \mathbf{ML}_{LS} is not considered in an isolated manner, regardless of the entire conceptual organisation in which it resides. In other words, the entire conceptual system is regarded as a whole, rather than dissected into its atomic elements. This forwards cognitive-linguistic understanding of conceptual systems (Chapter 5).

functionally embodied conceptual systems in the corresponding domains of discourse, this does not automatically mean that a given DSML always provides the same utility when used in the spectrum of purposes within the domain of discourse. Therefore, the success of a DSML in its linguistic function depends not solely on the extent of the functional embodiment of its underlying \mathbf{ML}_{LS} , but also on the utility of \mathbf{ML}_{LS} within $\langle mc, O, p, ML \rangle$.

6.6 Representational Function

In its representational function, the *representation system* (referred to as \mathbf{ML}_{RS} , see Figure 6.3), which is intended to facilitate the manifestation of \mathbf{c}_d into a purposeful model \mathbf{m} , i.e. artefact fit for the *intended purpose*, i.e. intended *audience* and *use* of model. This is in focus of the *manifestation* stream of modelling.

The representation system \mathbf{ML}_{RS} has thoroughly been studied in terms of qualities of syntactic-semantic code of \mathbf{ML} , as discussed in Section 6.3.1. More recently, the studies in visual notation quality by e.g. Moody [2009] also raised awareness on the role of visual symbols in processing models.

Given our focus in the thesis, we do not go into theoretical considerations underlying representational system of a modelling language. However, from our orientation, we propose to complement the considerations of representational aspects of modelling languages by the emphasis on the fact that \mathbf{ML}_{RS} actually mirrors the structuring of \mathbf{ML}_{LS} , allowing its ‘manifestation’ in two interrelated physical spaces:

- Physical space¹⁰ defined by the concrete syntax/notation, and
- Mechanical or technical space, defined by the syntactic-semantic restrictions incorporated in the abstract syntax and semantics of the modelling language.

Obviously, depending on the $\langle mc, O, p, ML \rangle$ setting, these two manifestation spaces will have different importance, specifically depending on the model purpose \mathbf{p} . Typically, the distinction between human and machine audience of models is made, to stress the different qualities required from the model for each. Likewise, two general classes of uses of models – more technically-oriented uses of model-artefacts vs. uses of artefacts for human-sense making and communication – are likely to stress/require different aspects of \mathbf{ML}_{RS} . For instance, while the quality of syntactic-semantic restrictions in \mathbf{ML}_{RS} comes to the fore for mechanical model manipulations (machine as the primary audience of the model), the emphasis is on the pragmatic and semantic aspects of models when it comes to the human audience and typically in the case of stakeholder communication [Bubenko et al., 2010, Hoppenbrouwers et al., 2005a]. Conceptual and enterprise models, however, lie at the boundary between technical and social world. In particular, in enterprise modelling,

¹⁰This physical space can be further characterised in terms of number of dimensions, such as 2D or 3D space, tangible or non-tangible, using single modality (e.g. image) or multi-modal space (e.g. image in combination with sound) [Zarwin et al., 2014].

as underlined also in [Barjis, 2009], model-being of an artefact **m** crucially depends on human (observer **O**) judgement. Even if the artefact **m** in the given **mc** is intended for the mechanical manipulation, it is still the human actor who is bound to make sense of created artefact and assess its *model-being*. Specifically in EM, the requirements with regards to the model manifestation in the visual space (next to the conceptual dimension discussed in Section 6.5) play a significant role, and need to be adequately accommodated.

Taking these factors into account, we suggest that a successful functioning of **ML_{RS}** in depends on:

- Recognisability of **ML_{RS}** visual symbols
- Quality of mapping between **ML_{RS}** and **ML_{LS}**
- Utility of **ML_{RS}** for $\langle mc, O, p, ML \rangle$

6.6.1 Recognisability of **ML_{RS}** Symbols

We refer to the recognisability of the symbols of **ML_{RS}** by the observer **O** within $\langle mc, O, p, ML \rangle$. The visual notation has its evident importance in the process of model creation, as it basically constitutes the ‘interface’ through which the modeller has access the linguistic structure of **ML_{LS}**. Given the parallel ‘execution’ of both conceptualisation and manifestation stream, **ML_{RS}** has the capacity to positively or negatively affect the effort needed in the understanding and use of **ML_{LS}** as well.

With this respect, different authors discuss the need for adapting the notation for the use by different stakeholders, e.g.[Bubenko et al., 2010, Frank, 2014b, Hoppenbrouwers et al., 2005a, Moody, 2009]. For instance, Moody [2009] suggests that visual notations should offer different visual variants, adapted for at least expert and novice modellers, in order to optimise their cognitive processing [Moody, 2009]. However, besides general optimisation of visual characteristics of symbols of **ML_{RS}**, their grounding in the domain of discourse may play an important role with this respect.

6.6.2 Relationship between **ML_{RS}** and **ML_{LS}**

As **ML_{RS}** mirrors the structure of **ML_{LS}**, it is equally important to consider the quality of the mapping between these two structures. Ideally, the visual symbols should correspond to the constructs of the modelling language, which can be summarised also in terms of *semiotic clarity*, suggested in the work of [Moody, 2009].

However, there is more to this than just the semiotic clarity dimension. Given that the conceptual structure is essential for understanding the individual concepts within a conceptual system, the choice of visual symbols for each individual concepts, as well as their coherence, play the role in communicating concepts and in ‘mirroring’ the underlying conceptual structure of a modelling language. The more specific factors affecting these aspects of the representational functions would have to be subject to empirical studies.

6.6.3 Utility of \mathbf{ML}_{RS}

As we have seen in Chapter 4, in a specific $\langle mc, O, p, ML \rangle$, the purpose \mathbf{p} governs requirements with regards to the model \mathbf{m} . This refers consequently, to the adaptation of ‘properties’ of the model artefact for the intended audience and use.

In enterprise modelling, the need to optimise the manifestation of the model more often concerns the adaptation for human-oriented consumption of representations. For instance, Moody [2009] suggests that, within the same linguistic structure \mathbf{ML}_{LS} , multiple representational variants should co-exist to allow for optimal cognitive processing of representations, targeted at least for different classes of audience, i.e. expert and novice modeller. Such an assumption underlies, for instance, the proposition of BPMN-variant which specifically targets business users, i.e. simple BPMN [Fernández et al., 2010]. The need for adaptation of model’s representation aspects for business stakeholders, and lack of such support by modelling infrastructures and modelling notations has also been reported by practitioners in [Anaby-Tavor et al., 2010, Bubenko et al., 2010, Malavolta et al., 2013].

This consideration is relevant not only for the ‘reading’ of representations, but also for the use of \mathbf{ML}_{RS} in the process of creating models. In this context, different classes of audience and different model purpose set different requirements on model visualisation. This has been discussed in e.g. [Hoppenbrouwers et al., 2005a, Proper et al., 2005] in terms of different syntactic, semantic and pragmatic qualities of modelling languages which are emphasised depending on the nature of modelling task and model use.

6.7 Summary

In this chapter, we studied the role of conceptual modelling language adopting the cognitive-linguistic orientation on conceptual knowledge, its structuring in language and use in conceptualisation. Based on this grounding and inherent utility orientation on language as a means to an end, we proposed that a conceptual modelling language has a twofold function when used in a modelling effort, namely a linguistic and representation function. The perspective we adopt on linguistic function underlines the need to consider the use as inherently related to, and interacting with, linguistic structure. This is also demonstrated in our proposition of the analytic framework allowing to better grasp the pragmatics underlying a certain linguistic structure in a modelling language. Additionally, we identify the major factors influencing the linguistic functioning of the modelling language. These provide the basis for elaboration of the explanatory theory.

Part III

Explanatory theory

Use of Enterprise Modelling Languages

In this chapter, we discuss the propositions of our explanatory theory, which targets understanding and explaining the factors of modelling language use in the context of enterprise modelling. At the same time, we also present the findings from the interpretive field study, and discuss them in the light of the explanatory theory. To this end, we proceed as follows. We first discuss the adopted research method are discussed in Section 7.1, and elaborate on the choices taken in shaping the detailed field study design in Section 7.2. The propositions of the explanatory theory are given in Section 7.3, and the detailed findings in relation to the linguistic function discussed in 7.4. We reflect on our findings in Section 7.5.

7.1 Method

The explanatory theory focuses on answering the following research questions:

RQ 3. *What are the factors that affect the use of enterprise modelling languages?*

RQ 4. *How can these factors explain the emergence of dialect-like variants of enterprise modelling languages in the actual contexts of their use?*

The explanatory theory relies on the conceptual framework developed in Chapters 4 and 6. More precisely, based on our theoretical propositions regarding twofold role of conceptual modelling language, we seek to understand and explain the use of modelling language in an enterprise modelling setting. We specifically seek for refining our theoretical understanding of the linguistic function of a conceptual/enterprise modelling language (Chapter 6). While

the linguistic function itself may not be the only source that affects the use of modelling languages, our hypothesis is that it is the least understood, and the most important in understanding language use in the context of enterprise modelling. Hence, the developed theoretical understanding of the linguistic function requires confrontation to the empirical data. In this context, we thus rely on the *correspondence theory of truth* [Frank, 2006], as illustrated in Figure 7.1 to evaluate our explanatory theory.

Interpretive field study. To this end, we engage in an interpretive field study [Klein and Myers, 1999]. The interpretive field study serves us as an additional material for refining theoretical reflection, and for controlling the breadth and depth of theoretical development. At the same time, through the field study, we operationalise the factors affecting modelling language use, and relate them to identified linguistic and representation function of the modelling language. At the same time, the interpretive field study also allows to get the feedback on the underlying reference theories.

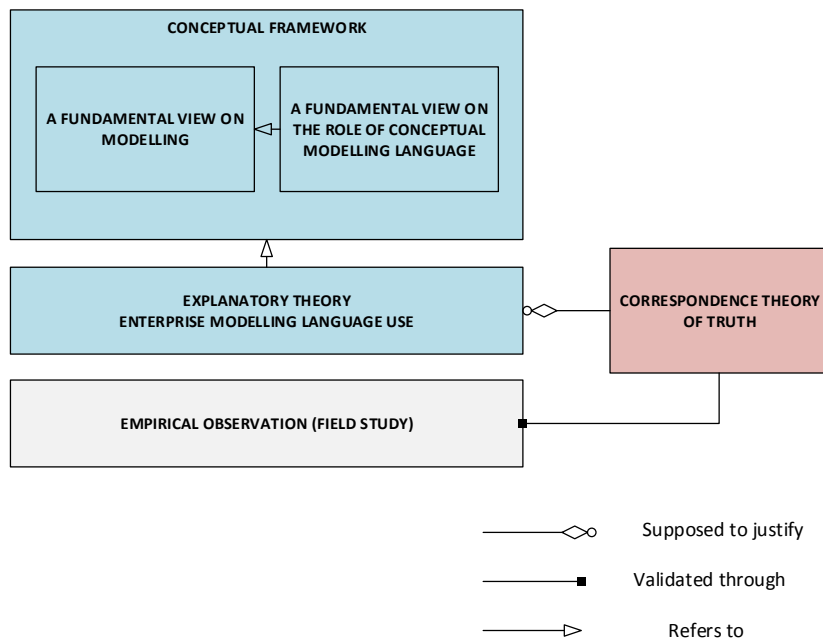


Figure 7.1: Explanatory theory, theoretical framework and justification context.

Qualitative data. Within the interpretive field study, we work with qualitative data, and perform qualitative data analysis relying on the guidelines of [Miles and Huberman, 1994].

The essence of qualitative analysis consists in an “*interactive cyclical process*” [Miles and Huberman, 1994], whereby each wave of data analysis allows

to reassess and identify the requirements for subsequent waves of data collection. This naturally supports the revision and refinement of researcher's interpretations, and leaves space for rethinking existing hypotheses, thereby supporting the hermeneutic cycle of interpretive research [Klein and Myers, 1999].

Qualitative analysis involves three major streams of work: *data reduction*, *data displays* and *conclusion drawing and verification*. They partially overlap with data collection, as illustrated in Figure 7.2.

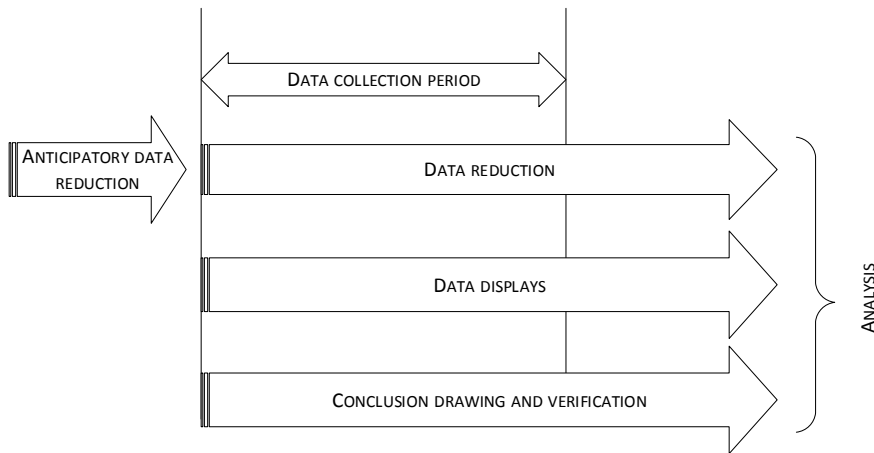


Figure 7.2: Streams of qualitative analysis, according to [Miles and Huberman, 1994, p.11]

Data reduction consists in on selecting and gradually transforming collected data, and arriving at a more condensed, sharpened views on data, which better lend themselves for deeper analysis and conclusion drawing. Additionally, Miles and Huberman [1994] specifically underline the importance of explicitly considering the series of decisions preceding data collection as *anticipatory data reduction* step: they concern the formulation of research questions, sampling decisions, conceptual definitions etc. Not only do they orient data collection, but have a major, though implicit, impact on all the subsequent analytic steps. Being explicit and transparent about data reduction decisions is in line with the principle of dialogical reasoning within interpretive research [Klein and Myers, 1999].

Data displays organise the condensed and reduced data to support reflection of the researcher on both macroscopic and microscopic level, and prompts him/her to look for other possible relationships and explanations of the events. They basically act as *data synthesising* and *puzzle posing* devices. Relying on the suggestion of [Miles and Huberman, 1994], we work with both *time-oriented* and *concept-oriented* data displays, allowing us to acquire both the holistic understanding of context, and to refine the (contextualised) understanding of specific phenomena within the field study.

Conclusion drawing and verification stream consists in formulating the conclusions about regularities and causalities in the case, and developing and/or testing the theoretical propositions. According to [Miles and Huberman, 1994], these activities are reserved for the later stages of analysis, where more emphasis is put on conceptual, inferential and causal understanding between the variables of interest.

7.2 Field Study Design

7.2.1 Criteria for Field Study Selection

To identify potential field study, we assessed the following criteria before selecting the field study, in order to ensure its feasibility for our research objectives¹:

Revelatory and confirmatory focus. Given the current state of theoretical development, we were oriented towards *confirmatory* and *revelatory* potential of the interpretive field study. To engage in a field study, we need to be able to assess upfront that there is a likelihood that the phenomena of our interest will occur. More concretely, we prioritised the field study in which an originally selected modelling language is likely (according to researcher's judgment) to be adapted or otherwise configured, in particular when it comes to its linguistic function.

Ongoing enterprise modelling effort. The researcher should be able to observe an ongoing enterprise modelling effort, i.e. it should cover modelling of (parts of) organisation, or some cross-organisational setting, such as networked organisation. We deliberately avoid relying only on the interviews with informants *ex post*, i.e. in a period following the modelling effort. The *ex-post* data collected from informants run the risk of being thin, context-stripped and unreliable, as informants may only selectively recall the events and decisions taken. Such a decision, however, requires from the researcher to be continuously in contact with project developments, and to be adaptive to dynamics, problems and challenges that may occur within the project execution, and in particular within a modelling effort.

Data access. Besides the availability of informants for the interviews, it is of utmost importance to have the access to models, related documentation, and other documents which may reflect decisions and reflections regarding the modelling effort and use of modelling language. In the process of identifying field study partners, the availability of such data has proven to be a sensible and, at the same time, critical issue. In several potential field studies, due to the increasing concerns regarding privacy and intellectual property in the

¹Although single field study is used in the development and refinement of our explanatory theory, we hereby discuss the selection criteria for the field study, having in mind a long-term perspective, i.e. further empirical evaluations and theoretical refinements.

companies, the access to models and related documentation would not be granted to the researcher. Within the selected field study (Section 7.2.2), the researcher was granted the access to full project folder, containing all the project documents, and model versions.

7.2.2 HEEL Project as a Field Study

HEEL project. The project HEEL, in the context of which happens the modelling effort we observe, is a project coordinated and mainly realised by a research and technology organisation (RTO) from Luxembourg. The project spans the period from mid-2014 to the end of 2015.

Project objectives. The objective of HEEL project is to define a common framework integrating the actors of the national health sector (such as hospitals, laboratories offering medical analyses, home care services, independent doctors, etc.) in terms of information management, and based on an enterprise architecture approach. This problematic arises from the national strategy of introducing an integrated patient health record, and the need to consider information security risks at the level of information exchange between all the relevant actors within the sector. The immediate focus of the project is the development of the portions of national sectorial reference architecture, which will set the foundation for the model-based approach to information security risk analysis tailored to the health sector.

Project participants. The HEEL project participants are the employees of the mentioned RTO, the staff of local governmental agency (who contributes to the project both financially and as steering committee member). The governmental agency acting as the main stakeholder in the project owns an in-house developed platform for semi-automated risk analysis, which is rather a generic one, and does not cover the specificities of health sector. The participants from this agency are consulted with regards to model progress and choices of modelling taken, and are the primary audience of models to be created.

The expertise in EA, conceptual modelling and risk analysis is brought by the employees of the RTO. As one of the outcomes, the prototype of model-based approach to risk analysis covering the health sector is meant to be deployed in the governmental agency mentioned. Within the modelling effort, the experts from health sector domain also take part, e.g. representatives of different professions, primarily the ones of (IT and business roles) national laboratories. The workshops are organised with these representatives, in order to better understand their professional activities, as well as aspects relevant for risk management. However, these stakeholders do not have an active role in model creation nor validation, as they are not intended as users of models being created.

The team of the RTO within the project has an additional ambition to demonstrate the power of models for addressing this kind of problem complexity.

While in the first place, models may be only addressing communication between human stakeholders, the goal of using models in the HEEL project is more ambitious, and goes beyond the project itself. From the perspective of respondent R₁, the ambition is to build the foundation for potentially automating to some extent risk analysis.

7.2.3 Scope of Observation and Sampling Decisions

The **focus** of our observation within the field study is the ongoing modelling effort. These phenomena are observed at two main levels:

- *Modelling* – We track informants’ evolving understanding of the modelling problem, and analyse the evolution of their opinions and decisions regarding the model shaping, as well as the use of the selected modelling language in that regard. This happens through insight into modelling choices across different model versions, documentation, and other relevant communication (documents). In addition, initially the observation (and recording) of collaborative modelling sessions were also assessed by the researcher as potentially relevant for understanding the modelling decisions and eventually the influence on modelling language use. However, within the HEEL field study, the time availability of participants presented an issue, and therefore, collaborative modelling sessions were not adopted, although initially envisioned, and modellers more or less coordinated their work on models.
- *Modelling language* – We track the use of modelling language, taking into consideration the point of time and reasons for modelling language selection, tracking challenges and decisions during the process, as well as a posteriori. These different points of time of our analysis and discussion with informants are intended to deepen our understanding of the moving target, e.g. understanding the reasons for modelling language selection, feedback regarding the value of modelling language used, challenges, and decisions related to modelling language adaptation.

Context analysis. To situate the observed phenomena in their context, we analyse the entire project to which the modelling effort pertains, in particular the ambitions and objectives of project that may relate to modelling. To this end, we use the available project documentation, and attend periodical project team meetings. In the HEEL field study, we attended and recorded two of these meetings, and while they are not transcribed, the relevant notes resulting from these meetings are used as integral part of analysis.

Triangulation. To strengthen the breadth and depth of our conclusions, in terms of obtaining *multiple perspectives* on the phenomena, we apply triangulation at following levels. We use *data triangulation*: we collect data from diverse sources, such as project-related documents, minutes of meeting, project documentation, team presentations, model artefacts, e-mail exchanges, internal documents that trace the decisions taken in structuring modelling approach, etc.

Additionally, in the analysis, we use different methods of analysis (method triangulation): we rely on document analysis, model analysis and semi-structured interviews.

In the interviews, we obtain the data from informants having different role in the modelling team. It should be emphasised here, however, that resource constraints in the realisation of the project (in our field study) led to a modelling team configuration with only one main modeller, and other modellers intervening *ad-hoc* and on the specific model aspects only. Therefore, while we had several informants in the interviews, their engagement in modelling was of limited scope, and only on specific model aspects. Therefore, their perspectives, although recorded in interviews and transcribed, are taken with caution. They mainly are used as complementary to the one provided by the main informant, as a means to prompt the research for the potential inconsistencies in the interpretations based on the main informant’s input. The informants consulted in the HEEL field study are enumerated in Table 7.1, with the first one having a major role in the data collection and conclusion verification.

Respondent	Project role	Modelling experience	Interviews
R ₁	Project lead and domain modelling expert	Expert, familiar with ArchiMate	All
R ₂	Domain modeller	Average, familiar with ArchiMate	04.10.2014, 17.11.2014, 25.11.2014
R ₃	Project manager and modeller	Beginner, not familiar with ArchiMate	04.10.2014, 25.11.2014, 15.12.2015
R ₄	Domain modeller	Has experience with process-oriented modelling, not familiar with ArchiMate	15.12.2015

Table 7.1: Interview respondents

7.2.4 Research Process Overview

The overall research process, as performed within the HEEL field study, is illustrated in Figure 7.3. The theoretical “pre-conceptions” imported in the field study through *anticipatory data reduction* (Section 7.1) consist of the *conceptual framework* underlying the explanatory theory (Figure 7.1) and *targeted research questions*, namely **RQ 3** and **RQ 4**. The latter are decomposed into a detailed set of research questions (See Appendix 9.5) and an initial coding list (Appendix 9.5), which orient data collection and analysis.

Each *data collection* wave is oriented by, on one side, the progress of

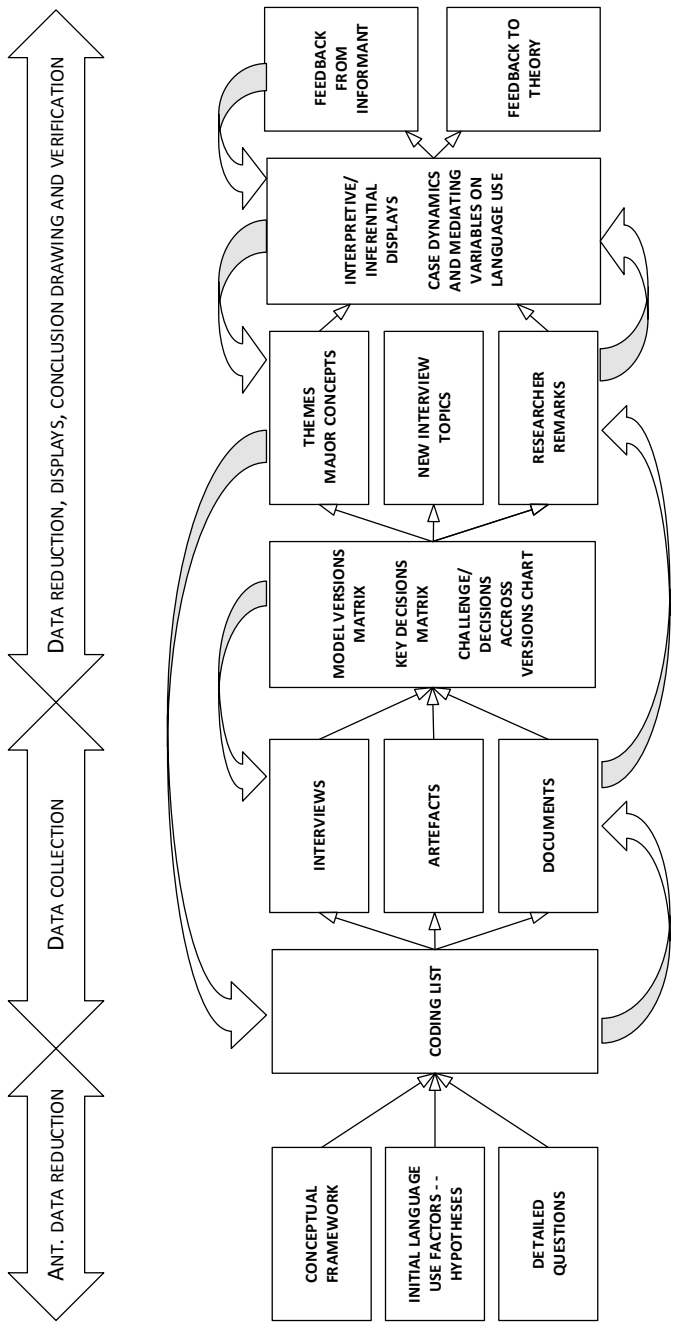


Figure 7.3: An overview of the research process within interpretive field study

modelling, and on the other side, by the topics on which further clarification is needed, or on testing the growing understanding and emergent explanations that emerge from data analysis, as illustrated in Figure 7.3.

In *data analysis*, we follow the recommendations of [Miles and Huberman, 1994] and move from high-level understanding of the processes and events towards more concept-oriented and inferential analysis. We thus identify main factors and develop the explanations regarding the use of language. The discussions with and perspective of the main modeller (R_1 in Table 7.1) are used as the main complement to our own interpretations, and as a means to verify our conclusions.

In the following, we discuss in more details, the choices made with respect to data collection, as well as instruments used in data analysis.

7.2.5 Data Collection

The following **data sources** are used to collect data in the specific project setting of HEEL:

Artefacts – In terms of artefacts, different model versions, and (if available) are kept track of and analysed. This allows to observe the modelling evolution and reflection, spot modelling- and modelling language-related challenges, modelling choices, as well as their potential revision in time.

Documents – The following kinds of documents are considered as potentially relevant data sources: project documentation, modelling method related documentation (if available), model-related documentation (if available). The exact documents to be used as data sources are obviously dependent on a particular configuration of the modelling effort, and other observed contingencies. In the HEEL study, we also used internal documents created by the modeller to structure the approach taken in modelling, as well as e-mail exchange, etc.

Semi-structured interviews are used as a platform to discuss about the modelling progress, diverse challenges and their management with relevant informants. Depending on the modelling progress and participants involved in the effort, interviews are held on an individual basis, or within a group setting. Table 7.1 illustrates the respondents involved in the interviewing sessions, while Figure 7.4 positions the interviews in relation to the modelling progress.

Semi-structured, rather than fully structured, interviews are chosen for the flexibility they leave for the informants to introduce topics and perspectives that the researcher might not have identified or perceived as important. This prompts the researcher to other subjects s/he might have missed to identify. Semi-structured interviews are prepared in terms of topics, with more or less precise questions for each topic. They set the boundaries for a particular interview, and define topics that should be addressed in the interview. Topics and questions are identified and prepared based on the preceding waves of data analysis, and based on open issues and puzzles noted by the researcher to

follow up on (e.g. noted in researcher's remarks). The question order is not strictly set, which gives the ample space to adapt to the conversation flow with the informant, and allow for the fluidity of interview process. At the same time, this also leaves enough space to develop on the topics that researcher might miss to identify. An example of question list for the interview are given in Appendix 9.5. Last, the interviews are held in the mix (per sections of conversation) of English and French, as these are the two languages used equally in the working environment of the researcher and within the field study.

7.2.6 Data Analysis

The analysis of collected data is performed with the support of software MAX QDA NVivo². The following instruments are used:

Interview transcriptions – The interviews are recorded preserving the original language of communication per each interview segment, and transcribed verbatim by the researcher. As French and English are the languages that the author of the thesis uses fluently in daily life, the bilingual communication is not a factor affecting the quality of data analysis. Where the citations of our respondents are used in the thesis, they are translated to English by the researcher, if originally they are not already in English.

Document summaries – Each relevant document used is synthesised in a one page summary, which provides a useful high-level overview, pointing at major topics covered in the document, and indicating the main puzzle or reflection points for the researcher. These document summaries are helpful in guiding data reduction and throughout the analysis support easier navigation through the material.

Artefact summaries – Apart from the original model diagrams which are used in the analysis, model and meta-model versions are also summarised in one page documents. The examples of high-level summaries of model versions are provided in Appendix 9.5.

Coding – All the relevant summaries and interview transcriptions are imported and stored in nVivo tool. The first step in their analysis is their coding. In all the simplicity, codes are “tags and labels for assigning units of meaning to the descriptive or inferential information compiled during a study” [Miles and Huberman, 1994, p. 56]. While it is an early analysis step, the process of coding fosters reflections, and allows easier navigation through the selected chunks of information (specifically when supported with a software tool). As already discussed in Section 7.1, the initial coding list is defined based on the theoretical framework and initial research questions, and identifies the major themes and concepts to follow up on, as identified at the beginning of the field study. Such coding list is reorganised and revised through the

²<http://www.qsrinternational.com/what-is-nvivo>

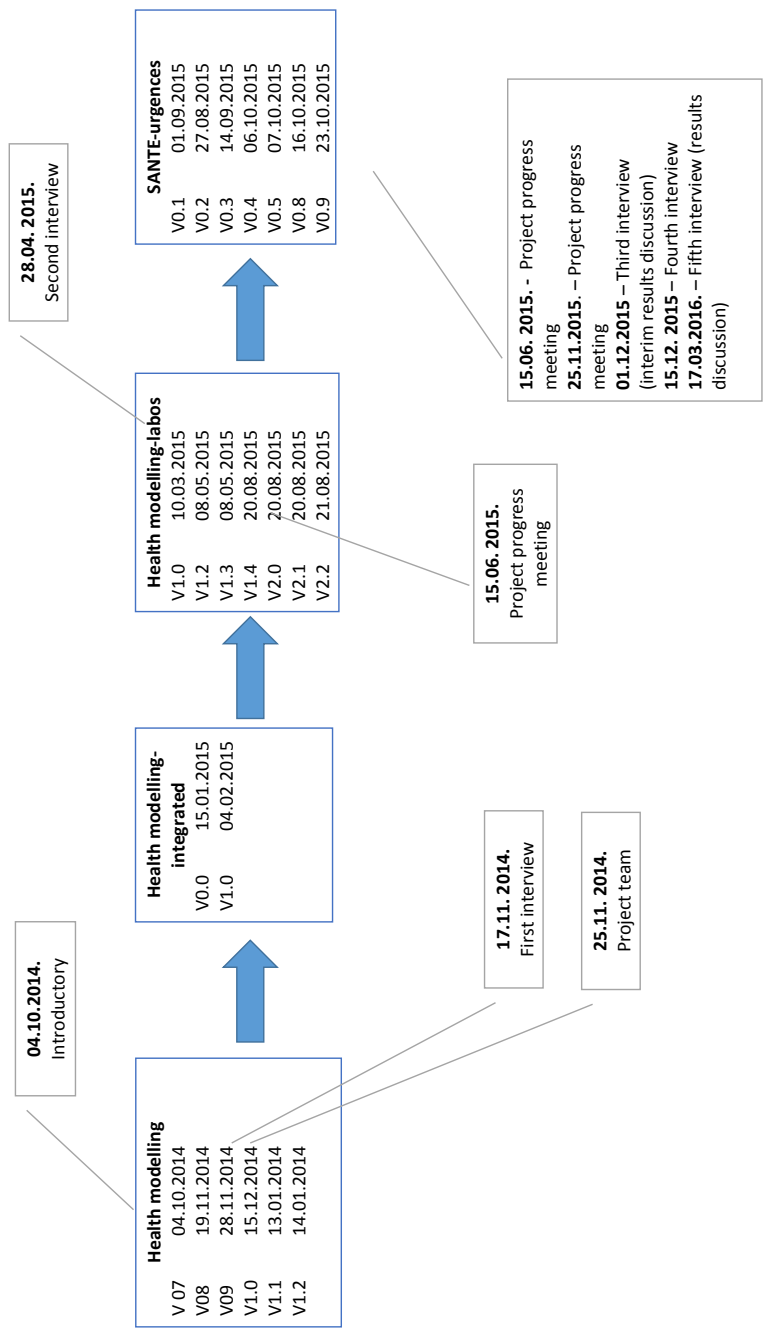


Figure 7.4: Time-oriented view on modelling progress in relation to the interviews held in the HEEL field study

entire process, potentially with each new waves of data collection and analysis. Various versions of the coding lists are preserved by the researcher, outside of nVivo software. The initial and final coding list, provided in Appendix 9.5 and 9.5 respectively, illustrate the extent of revision and refinement that takes place throughout the analysis.

Researcher remarks and memos – Researcher’s remarks are noted in each of the document summaries to identify the topics to follow up on, while memoing is typically used to note the researcher reflection and ideas that occur “on-the-fly” through the analysis process. Memos are stored in nVivo, and used as an aid for analysis and conclusion drawing.

Intermediary data displays – Based on the coded data, a high-level and time-oriented overview of the modelling progress is developed. This main display allows a global understanding of event ordering, model development, and also identifies key modelling challenges and decisions addressing them. The challenges and decisions are classified in those that only tackle model-related issues, and those that pertain to the modelling language. For a deeper analysis of major themes, main concepts and discovery of some causalities, different matrices and cause-effect diagrams are used. The structure and illustrations for each of the instruments used are provided in the Appendix 9.5. These matrices were oriented on deepening the understanding of the key challenges and related modelling decisions, as well as identifying and testing the causalities and potential explanations for these. Based on this, case dynamics matrix and diagram were detailed 9.5. These served as the basis for subsequent discussions, drawing of explanations of factors that affected language use, and were used also as input while getting informants feedback.

Fishbone diagrams – Finally, to visualise the influence of (main and enhancing) factors affecting the use of modelling language and the eventual emergence of dialect-like variant, we use the fish-bone diagrams, also known as Ishikawa diagrams³, due to the author who popularised their use in quality management. These diagrams are interesting in showing the influence of causes and their influence on creating the effect, and allow for decomposing the factors/causes in a hierarchical manner. The generic example of such a diagram is illustrated in Figure 7.5. We use the fishbone diagrams in two different ways:

- *First*, when presenting the theoretical propositions, we visualise the identified variables and their influence on language use. In this respect, the identified high-level variables are furthered detailed in terms of specific factors. The variables taken together contribute to creating an effect, e.g. decisions with regard to the use of selected modelling language (See Figure 7.7).
- *Secondly*, when presenting the empirical findings, the ‘categories’ of the fishbone diagram stand for the identified theoretical variables/factors,

³https://en.wikipedia.org/wiki/Ishikawa_diagram

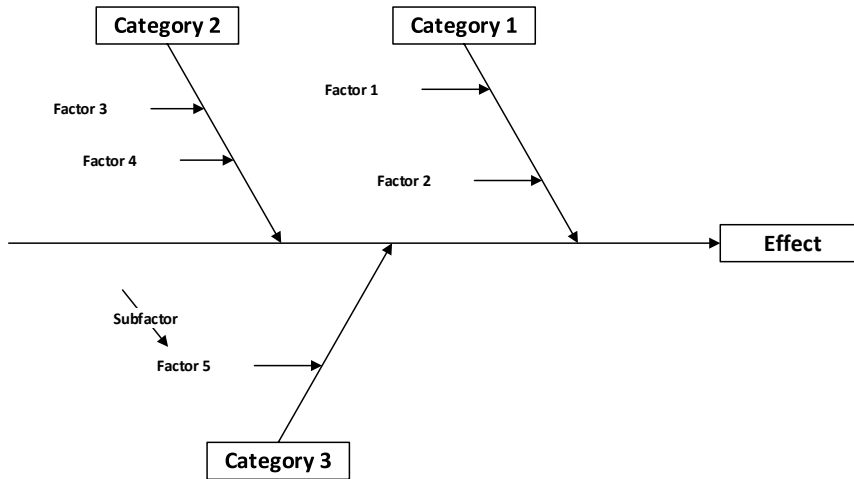


Figure 7.5: Generic fishbone diagram used to visualise causes and hidden causes of some problem/effect.

while the ‘factor’ of such fishbone is used to illustrate the specific ‘instances’ of the ‘category’, as found in the concrete field study. This second way of using fishbones also allows to make explicit the researcher’s interpretations of the events in the field study, as based on theoretically introduced concepts. The nature of influence of each ‘factor’ is characterised using the sign “+” (positive or creating value) or “-” (negative or inducing costs) where appropriate (e.g. see Figure 7.8).

7.3 Pragmatics of Enterprise Modelling Languages: Overview of Findings

Based on our theoretical framework developed in Chapter 6, we propose the study of enterprise modelling language use based on its linguistic and representational function. The theoretical development however was strongly focused on the linguistic function. This is based on the position taken: we believe that linguistic function of the modelling language is crucial, and in light of challenges with modelling language engineering and practice, we claim that the linguistic function of the modelling language needs better theoretical understanding.

While we are fully aware that the mutual tension between linguistic function and representational function is an important topic, it remains for the time being outside of our scope. To address such a topic, it is our view that a theoretical understanding of the linguistic function needs to first be properly empirically validated, before the mutual tension between the functions can be analysed from a more encompassing perspective. Consequently, the validation

of theoretical understanding of linguistic function is considered crucial in the context of explanatory theory.

Operationalisation. Towards empirical validation, the notion of linguistic (and representational) function is ‘operationalised’ relying on the notion of **cost-effectiveness**, as inspired by [Rothenberg, 1989] and introduced briefly in Section 6.4. The cost-effectiveness as a ratio reflects the result of trade-offs made when taking decisions regarding the use of a modelling language within modelling effort $\langle mc, O, p, ML \rangle$. This ratio is a cumulative, i.e. it is a consequence of the gradual evaluation of the modelling language in its functions throughout the entire modelling effort. The overall cost-effectiveness of a modelling language in its use of course depends on the cost-effectiveness of both its linguistic and representational function. Furthermore, depending on the modelling effort $\langle mc, O, p, ML \rangle$, linguistic and representational function may have different relative importance over each other, and may ‘compete’. It is known that these functions are to some extent in conflict, and that dealing with this conflict is a major challenge of language engineering.

In this context, the ‘positive’ ratio then corresponds to the favourable trade-off, i.e. the situation where added value of using a modelling language is (assessed as) greater than involved efforts and/or problems. Conversely, the ‘negative’ cost-effectiveness ratio reflects the unfavourable trade-off, whereby the effort required overcomes the added value of using a modelling language. Note that these ratios are used as approximations only, i.e. as the means to operationalise the analysis of language use.

In the following sections, we present the propositions of the explanatory theory, which results from previous theoretical development and refinements stemming from the conducted field study. First, we provide a high-level view on our findings in Section 7.3.1, while the details regarding the validation of linguistic function framework is discussed in Section 7.4, and the resulting insight into and tentative characterisation of language variation is discussed in Section 7.4.7.

7.3.1 Factors in Use of Enterprise Modelling Language

We propose that the primary factors shaping the use of a conceptual / enterprise modelling language relate to its cost-effective functioning in terms of linguistic function and representational function. Other factors only attenuate these primary factors.

The detailed look at all the underlying factors, discussed in the following, is given in Figure 7.7.

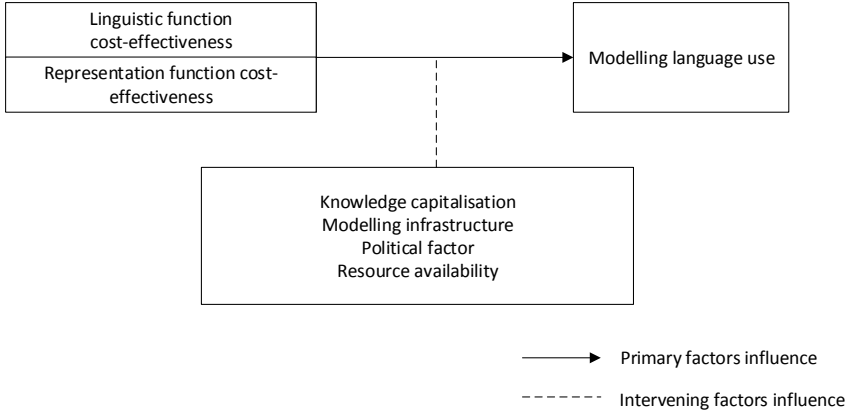


Figure 7.6: High-level view on relationships between main variables

Linguistic function cost-effectiveness. The cost-effectiveness of linguistic functioning of a modelling language depends on the combined effect of the following factors (See Figure 7.7):

- **Degree of ML_{LS} embodiment by observer in $\langle mc, O, p, ML \rangle$** – The degree of embodiment ML_{LS} acts as a facilitator of effortless adoption of ML_{LS} to act as the mediator of conceptualisation.
- **Utility of ML_{LS} for $\langle mc, O, p, ML \rangle$** – The adequacy of conceptual perspective and structure provided by ML_{LS} for domain conceptualisation contributes positively to the cost-effectiveness of linguistic function.
- **Pragmatic coherence of ML_{LS}** – A clear pragmatic rationale underlying ML_{LS} (as a conceptual system) acts as the enhancing factor, which is likely to positively affect ML_{LS} affects its understanding. Consequently, we conclude that it can not only diminish the effort required for the use of ML_{LS} , but also facilitate the evaluation of the utility of (parts of) ML_{LS} .
- **Method-like guidance accompanying the use of ML_{LS}** – The presence of some form of method-like guidance accompanying the use of the conceptual system ML_{LS} positively affects its understanding, and diminishing the effort required for the use of ML_{LS} , and may also attenuate the negative affect of the lacking pragmatic rationale in ML_{LS} .

A high-level view of our conclusions derived in the explanatory theory development are depicted in Figure 7.6. While the first two factors, namely embodiment and utility are identified in the theoretical framework, the nature of influence of the *pragmatic coherence* and *method-like guidance* factors have been derived based on the empirical insight. The detailed discussion about these individual factors and their influences is presented in Sections 7.4.3– 7.4.5.

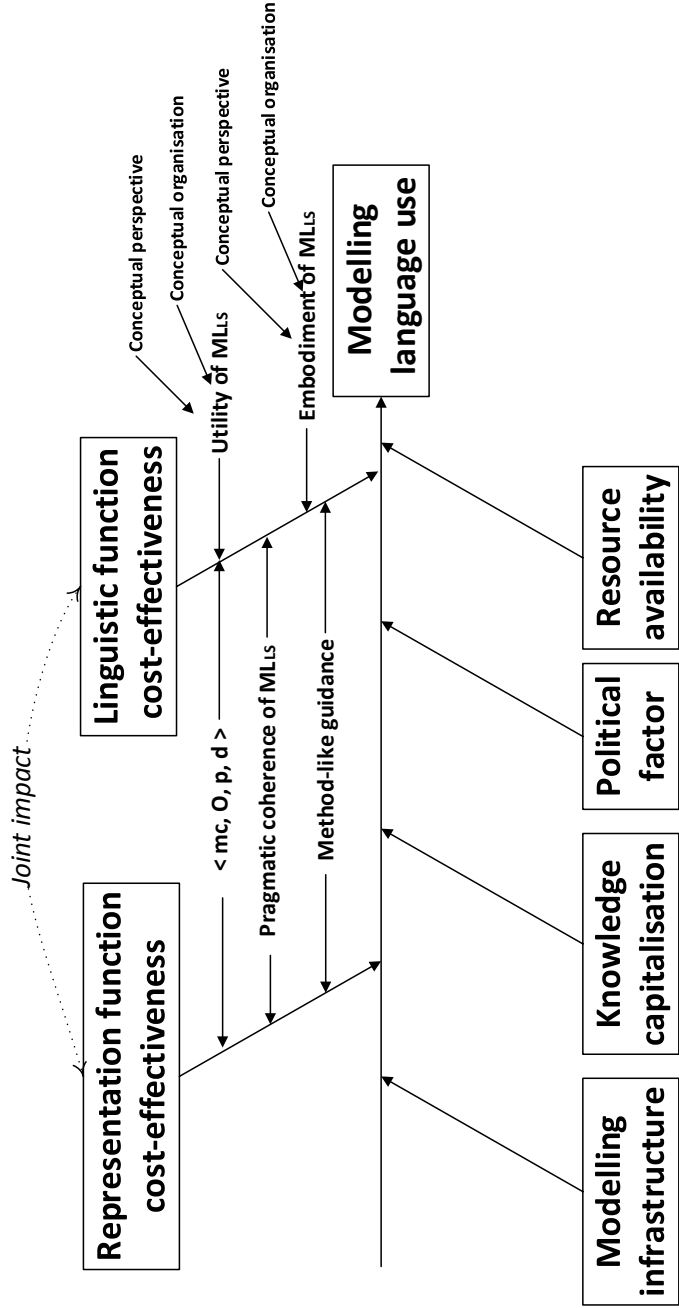


Figure 7.7: Factors Of Modelling Language Use

Note that in Figure 7.7, both method-like guidance and pragmatic coherence as factors are positioned as pertaining both to the linguistic and representational function. However, their impact to representation function remains to be further empirically investigated.

Representation function cost-effectiveness. As already discussed, the representation function was not in the focus of the present theoretical development and validation. However, drawing on previous discussions in Section 6.6, we propose to analyse the representational function in terms of the proposed dimensions in Section 6.6. As also the visual notation may impact the effort of understanding and use the linguistic structure, we indicate, in Figure 7.7, that these functions have a *joint impact* on the use of a modelling language. A more elaborate analysis, evaluation and refinement of factors relative to representation function remains a task for further research.

7.3.2 Intervening Factors

While main factors stem from cost-effective linguistic and representation function, we do not claim that these are the only factors that shape the use of an enterprise modelling language. We identify several *intervening factors* (See Figure 7.6) that may in further *constrain* or *enhance* language use, have a mediating effect on the primary factors.

Based on the empirical evidence, we identify the following factors: *modelling infrastructure*, *knowledge capitalisation*, *political factor*, *resource availability*. These factors should however be considered as only illustrative of the specific field study, and not generalisable. The concrete factors and the nature of their influence (positive or negative) are always context-specific. What is, however, important, is that the identified factors may stem from the wider environment of the concrete modelling effort. They may be present both in selecting and using the language, as well as affect the choices of modelling language adaptations.

Modelling infrastructure. The *modelling infrastructure* hereby refers not only to model editor/modelling tool, but also to the entire model management infrastructure which is set up in the given enterprise or enterprise modelling setting pertaining to the modelling effort. While modelling infrastructure is not discussed in the theoretical considerations in Chapter 6, it usually forms an integral part of a modelling language application context, and as such should be taken into account. The technological choices often constrain the available functionality or choices in a modelling setting, and therefore may impact how modelling language is used. In the field study, the use of ArchiMate model editor constrained the options with regards to the possibilities of language adaptation, for instance.

Political factor. In the field study, there was a political pressure to use ArchiMate within the project. In the concrete situation, the pressure was

not so strong, as modelling team could have changed theoretically changed the choice of a modelling language along the project without political consequences. Nonetheless, this choice clearly impacted the orientation of the entire modelling exercise, and contributed to the language variant emergence as well. Finally, one can easily imagine the pressure of using the standard could be so strong, and does not leave any other option, even if the choice is inappropriate. In that case, the language functionality can be seriously hampered.

Resource availability and knowledge capitalisation. Within the field study, the choice to reuse an existing modelling language and to adapt it, rather than define the appropriate language from scratch, relates both to the need/desire to reuse/capitalise on existing knowledge and best practices incorporated in a standard language for EA, and the lack of resources available for the development of modelling infrastructure which supports on-the-fly reconfiguration and adaptation of the original language. As such, resource availability intervenes not only in modelling language selection, but also impacting the decisions on the form of language adaptation (See Section 7.3.3).

7.3.3 Language Adaptation

We propose that a ‘negative’ cost-effectiveness ratio of a modelling language lies at the root of decisions that lead to the emergence of modelling language variant. However, the form that the modelling language variant takes in the concrete modelling effort is dependent on other intervening factors.

The intervening factors impacts which decisions are taken to compensate for the ‘negative’ cost-effectiveness of the modelling language, and thus the form of modelling language variant. In this context, we distinguish between the **implicit** or **explicit** language variant.

The **implicit language variant** refers to the situations when there is a strong pressure or constraint to remain within the boundary of selected language/tool, and thus the solutions for the ‘negative’ cost-effectiveness have to be sought in the limits defined by the modelling infrastructure. In this case, the usual strategy is to use generic constructs such as Package, Comment, Tag, etc. available in language/tool, or also to ‘abuse’ some generic and vague constructs within the modelling language, where possible, to compensate for the missing elements. The examples of such strategies are reported on in e.g. [Anaby-Tavor et al., 2010, Malavolta et al., 2013, Recker, 2010], and is general common in the practice.

On the other hand, the **explicit language variant** refers to the use of explicit mechanisms for language adaptation and refinement, such as defined in e.g. [Frank, 2014c, Oei et al., 1992, Zivkovic and Karagiannis, 2015]. Within the field study, we observe that the desire to reuse the particular conceptual structuring and the way of thinking reflected in a modelling language variant was one of the main motivations for more explicit adaptation of the modelling language. However, this was not completely achieved in the given modelling

project, due to the combined negative influence of other intervening factors.

We identify that such strategies may be chosen due to the *negative* influence of political factor (e.g. pressure to use the modelling language, pressure of standard, etc.), modelling infrastructure (un)available (e.g. the organisational choice of existing infrastructure that does not allow the more explicit language adaptation), and/or resource availability (e.g. not enough resources to invest into the language adaptation/specialisation).

7.4 Linguistic Function: Detailed Findings and Discussion

In this section, we present detailed findings regarding the use of enterprise modelling language in the context of our interpretive field study.

7.4.1 Modelling Language Selection

As previously discussed, we consider that understanding the reasons for selection is important for properly understanding its subsequent use in a modelling effort.

Insights from HEEL field study. The concrete ‘instances’ of factors affecting selection of the modelling language in the HEEL field study, given in Figure 7.8, are discussed in the following.

ML_{LS} conceptual perspective. In terms of elements of ArchiMate, the a priori reflection regarding the selection of this modelling language considered its holistic perspective on the enterprise, as well as the core concepts offered for enterprise modelling (ML_{LS} core concepts). The team expected to be using the enterprise modelling concepts in the project, therefore selecting ArchiMate seemed as natural. At the same time, the fact that it allows a holistic view on the enterprise was an advantage, as ArchiMate models are considered as potential candidates for hub models that assure or otherwise facilitate integration with other models that might be used in the modelling exercise.

ML_{LS} conceptual organisation. Another important feature of ArchiMate that played the role when selecting the language were the mechanisms that allow management of complexity in modelling, e.g. layers and viewpoints in ArchiMate. These reflect the detailed *conceptual organisation*, but also are integral part of the visualisation mechanism in ArchiMate, i.e. its *representation function*. The analysis of utility of ArchiMate beyond just the core concepts was not done before its use within the modelling effort, as the shaping of the domain **d** and purpose **p** were not fully known. It noteworthy that, at the point of time when selecting the modelling language **ML** for the given modelling effort $\langle mc, O, p, ML \rangle$, the selection of **ML** is based on the initial and incomplete understanding of the domain **d** and purpose **p** of the model-to-be-created. Consequently, the assessment of linguistic and representational functions is also incomplete, and potentially not adequate.

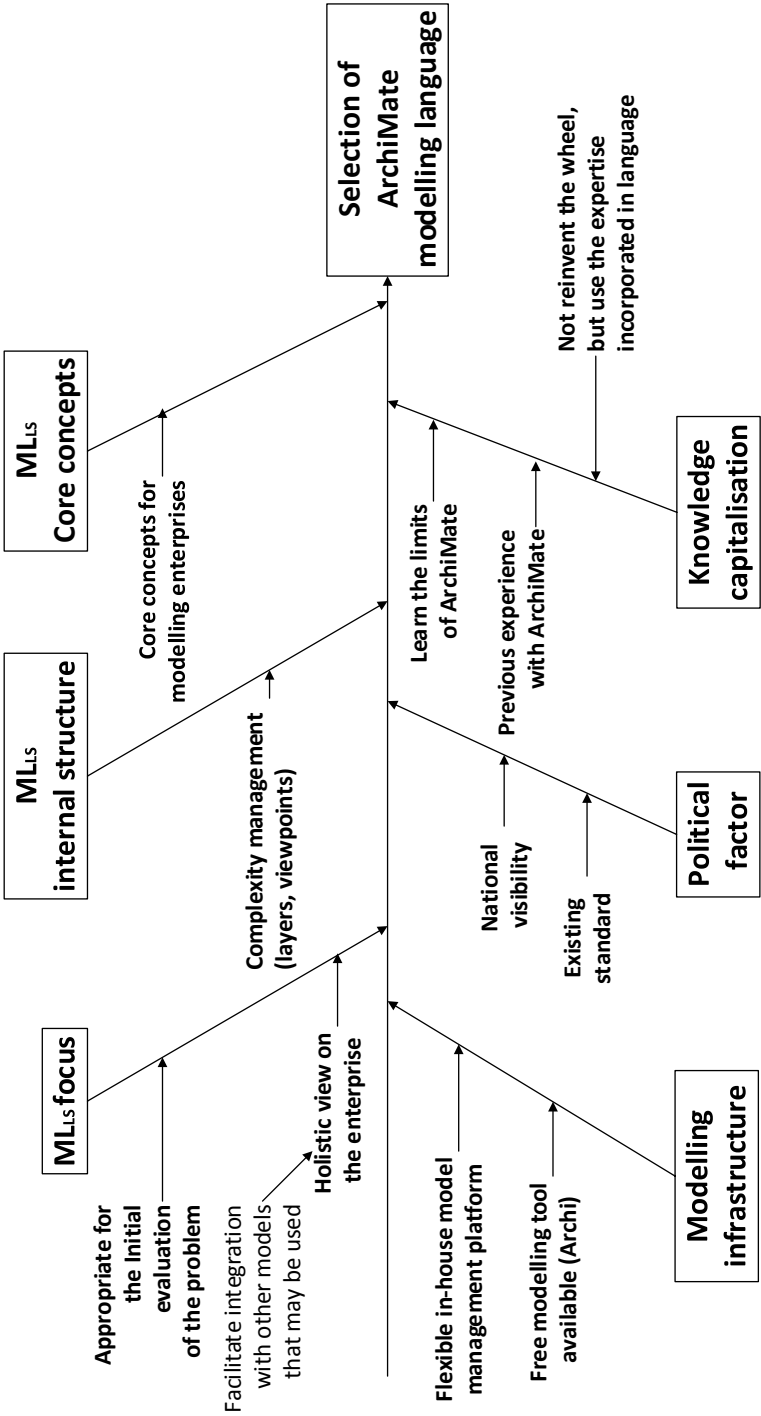


Figure 7.8: The factors of ArchiMate selection in the HEEL project

In conclusion, based on its core concepts, holistic and high-level perspective on the enterprise (ML_{LS} focus), as well as mechanisms provided for complexity management, ArchiMate was assessed as adequate for the problem that project team understood to face:

R₁: “We are however facing here a complex system, we have rapidly seen, that powerful modelling elements, typically viewpoints, the fact to be able to separate different aspects of the system while still keeping their coherence, this is something we really use. We are incapable to all represent in a single diagram, we are humanly not capable of processing the complete model. We need something, not only the modelling tool, but I am convinced something underneath that can reason on such models.”

(17.11.2014)

In selection of the ArchiMate in the HEEL project, several other factors intervened.

Political factor. ArchiMate was suggested to the project team as a politically correct choice by the management of the RTO whose members had the lead technical role in the HEEL project. While the existing expertise within the RTO was certainly an influence, the political aspect in this context refers to the need for visibility of EA/EM related capacities and competence at the national level. Because of previously mentioned functional factors, this political influence was not initially considered as a major constraint by the project team.

Capitalisation of knowledge and resource availability. The reuse of an existing modelling language was considered important by the team, as it allowed them to start by reusing the existing knowledge incorporated in the defined language standard. Beside assuming that this allows to reuse some best practices, it also was important in terms of saving time on the project, and optimising available resources. Furthermore, the desire to learn about the limits of ArchiMate application was present from the beginning in the reflection of the main informant R₁. This influenced also the decision to explicitly trace the use of ArchiMate throughout the modelling effort.

Modelling infrastructure. The selection of ArchiMate was facilitated by the existence of the free of charge modelling tool, Archi⁴. Additionally, there was an unclear intuition within the project team that ArchiMate or any single modelling language may not be sufficient for the problem that is being faced. This influenced the use of an in-house model management platform as a main model repository and for prototyping the solution for the integration between sectorial models and risks. Archi was only used as the model editor for ArchiMate models, however all the manipulations of created models were performed outside of ArchiMate environment, in an in-house model management platform.

⁴<https://www.archimatetool.com/>

7.4.2 Conceptualisation Stream: Levels of Reflection

In Section 6.5.4, we forwarded the hypothesis that within conceptualisation stream, there is a ‘competition’ and continuous interaction between *ML-independent conception of domain* and *ML-mediated conception of domain*, in which the cost-effectiveness of linguistic function is being ‘negotiated’ and evaluated. Consequently, in this process, we observe the impact of the factors relevant for the linguistic function, as illustrated in Figure 7.9.

Based on the empirical insight, we observe that this continuous interaction between *ML-independent conception of domain* and *ML-mediated conception of domain* indeed takes place in conceptualisation stream. Within the field study, we ‘operationalise’ the observation of these levels of reflection in conceptualisation stream by identifying modelling challenges and modelling decisions, based on available artefacts and documents. These are then discussed in interviews with respondents. The progress of reflection in the modelling effort is visualised at high-level as depicted in Appendix, Figures 16–18. These figures depict modelling challenges and decisions as they relate to different model versions, and modelling language use. This allows a more detailed insight into reflections regarding the domain **d** being delimited and structured, purpose **p** being clarified, model-to-be **m** being shaped, and the use of selected **ML** in this context. During the analysis, we observe that a number of challenges and decisions are clearly independent of **ML** used in the modelling effort, and concern shaping of *ML-independent conception of domain*.

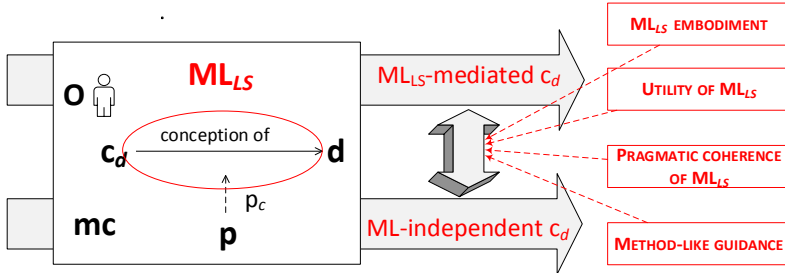


Figure 7.9: Overview of Linguistic Function factors.

Insights from HEEL field study. For instance, this continuous interaction can be observed in a high-level visual representation of the progress of modelling across model versions, in Figures 16–18. Namely, within the ‘red’ stream of conceptualisation, one can observe two levels of reflection:

- One level of reflection is to a significant extent independent from the concrete meta-concepts of ArchiMate language, i.e. *ML-independent conception of domain*. It addresses the clarification of the perspective, focus, required topical coverage, level of detail of the domain conceptualised, and in relation to both the context **mc** and purpose **p** of the concrete

modelling effort, i.e. shortly it regards the delimitation and shaping of the domain **d**. Nonetheless, this level of reflection is not totally detached from the basic framing provided by the selected modelling language ArchiMate, as the latter is the part of modelling effort background, and at least some core concepts orient the way in which initially the domain **d** is structured (Note that this core of ArchiMate consisted one main reason for its selection for the given modelling effort). As we will discuss later in this section, we believe this impact of ArchiMate is related to the degree of embodiment of ArchiMate by the modeller.

- Another level of reflection involves questions regarding the interpretation, adequacy and use of ArchiMate's concepts for expressing the domain **d**.

The framing of processes in conceptualisation in terms of different levels of reflection demonstrates *analytic utility*: it allows for their separate, but parallel, as well as for the analysis of their 'interaction points' where the use of a modelling language is discussed.

7.4.3 Embodiment of ML_{LS} in Conceptualisation

In Section 6.5.4, we propose that the observer's familiarity with ML_{LS} presupposes its effortless adoption in conceptualisation processes. The more experience an observer has with the ML_{LS} or a-like modelling language, the less effort its adoption of ML_{LS} for the conceptualisation requires, and ML_{LS} has more potential to spontaneously mediate the conceptualisation of domain. Conversely, the less experience and expertise in modelling an observer has, the less likely ML_{LS} is to be acting as a mediator of conceptualisation.

Insights from the HEEL field study. Based on the empirical evidence, we also have the indication that totally clear separation between *ML-independent conception of domain* and *ML-mediated conception of domain* within conceptualisation stream depends on the degree of embodiment of ML_{LS} and to the successful functioning of ML_{LS} . Namely, given the profile of our main informant R_1 (See Table 7.1) who had the observer role in the modelling effort, we interpret this finding as the very effect of the embodiment in conceptualisation: our main informant R_1 had a long-term modelling expertise, as well as a previous experience with the modelling language used in the field study, ArchiMate, as well as many similar modelling languages, e.g. UML [OMG, 2005] and BPMN [OMG, 2011]. While not having used the entire spectrum of ArchiMate constructs, the informant R_1 was used to ArchiMate's 'way of thinking' in general, and could easily adopt it in the modelling effort. Consequently, we interpret that, because of this degree of ML_{LS} embodiment by the R_1 , the use of ML_{LS} as a mediator of conceptualisation was in some aspects – relating in this concrete study to the *conceptual perspective* of ArchiMate – spontaneous and automatic, thus to a certain extent obscuring a clear-cut distinction *ML-independent conception of domain* and *ML-mediated conception of domain* in his considerations. This is illustrated in the following discussion:

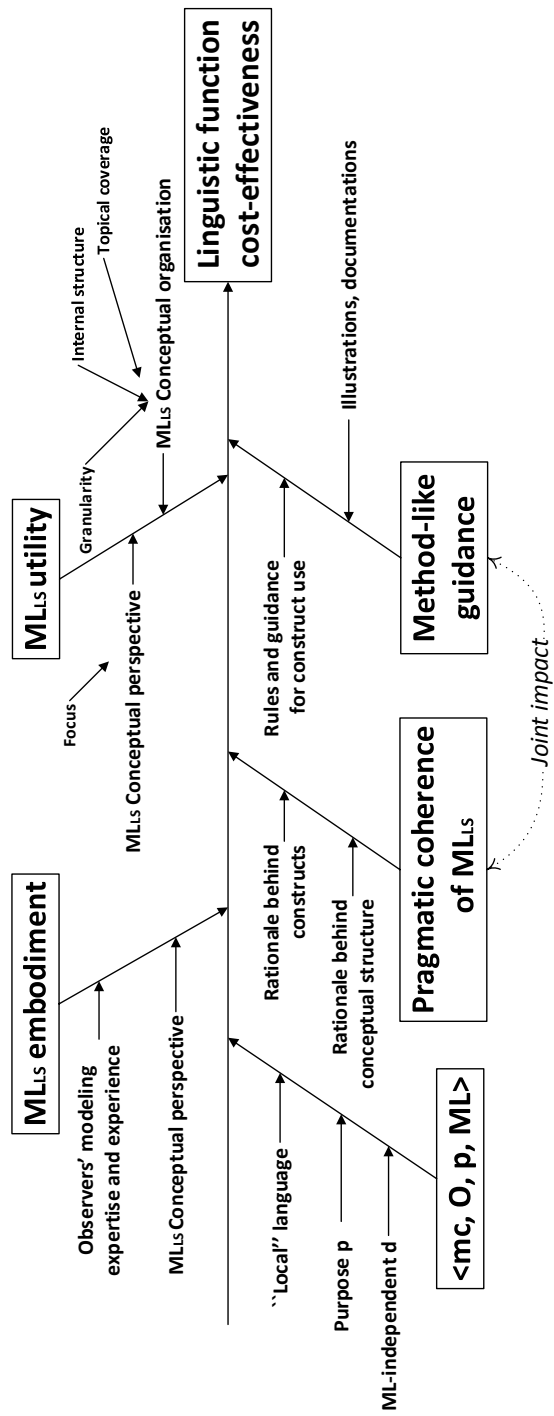


Figure 7.10: Cost-Effectiveness of Linguistic Function: Factors

R₁: “Generally, I do not like this, maybe it is personal, but the fact that we directly use ArchiMate... The model here, we can produce it with anything, because after all.... The fact that we use the concepts of ArchiMate, that helps us in terms of allowed associations, it allows us not to have to define each concept. For instance, we use Role, therefore this means competencies etc. At the same time, this is almost like we were doing a conceptual mapping, an implicit one, without really doing it.”

Researcher: “I did not get you.”

R₁: “So, if we wanted to really do the thing properly, completely correctly, I think we would have to construct our own reference model independently from ArchiMate, and then if we wanted to use ArchiMate, we would have to do the mapping between the concepts. The mapping, if it is mapping I do not know, but start to analyse if the role that we use and define is the Role defined in ArchiMate... If yes, then I can use the concept of ArchiMate. And maybe it is not the same, and then.... Well, this process we have not done here...”

Researcher: “But what is however important, it seems to me, is that you clarify how you are going to use these two concepts... [Actor and Role]...”

R₁: “Yes, exactly. But, indeed, we can arrive at a clash, meaning that our concepts of Actor and Role do not correspond finally to the concepts in ArchiMate.. Maybe... This is a bit like.... As if we took it as the basic postulate that ArchiMate [meta]model is a [meta]model of the system that applies to the health sector... That language describes, or is sufficient for describing the health domain. We haven’t done the exercise to prove it. Well, this we have not done also because we have seen this project as.... We have selected ArchiMate and at the same we have said that this project is an experiment... If we have problems [with ArchiMate], we will be able to identify what these are...”

(17.11.2014)

However, the ‘interaction points’ in modelling process where clashes between required and provided linguistic support in conceptualisation are identified correspond also to the situation where the above-mentioned levels of reflection become more clearly separated. This, in our view, reflects the moments where concepts of **ML**_{LS} are consciously pondered and reflected on, thereby ‘breaking down’ the unconscious and spontaneous mediating role of modelling language on conceptualisation.

R₁: “Where do you put, for example, I want to represent something with the predefined language, and at a certain moment of time I will have to make mapping of concepts, because my concept, I cannot represent it [with the predefined language]. For instance, here, we have Capability, but we do not have it in ArchiMate, and so what are we going to use? We use Business Function.

Researcher: “For me, it is at this level [showing the linguistic function in the schema].”

R₁: “Ok, we say at this linguistic level, I use a new concept, but I re-use the existing ArchiMate concept... ”

Researcher: “In effect, here [linguistic function] there are two levels, this question if Capability is suitable for this abstraction of sector, this is the question that exists independently of ArchiMate..... ”

R₁: “Exactly.”

Researcher: “And then, once you have said ok, this is the level of abstraction for this and that reason, now how do I do it in ArchiMate... What is interesting for me is the interaction between these levels... Because anyway you have to frame the domain linguistically.”

R₁: “Yes.”

(01.12.2015)

Given the limited empirical evidence, we are not in position to further analyse the effect of a lesser degree of embodiment on the linguistic function, both generally and in a specific case of a novice modeller. Note that, aside of the main expert modeller, we had other respondents and participants of the modelling effort. Namely, the respondent R₃ was the novice modeller, while the respondent R₄ was new to using ArchiMate language. However, the modeller R₃ took over the modelling of a specific part of model only⁵ in the later stage of the project *and* once the adopted modelling approach was structured and made explicit. Additionally, R₃ was instructed regarding the adopted modelling approach, and the work of R₃ served more as the experimentation with the approach defined by R₁. To conclude, given that the model developed by R₃ and R₄ remained in initial stages, and applied the already defined modelling approach, these efforts were left out of scope of the analysis. Effectively, the given circumstances made that these efforts cannot be commensurate to the use of originally selected language by the novice modeller,

⁵The part of the sectorial model developed by R₃ was specific to one actor type (i.e. ambulance), and remained only as at draft version. This part of the model was not based on the concrete understanding of the business and needs of ambulance actor type, and served more as experimentation with the modelling approach. The situation was similar with the implication of the respondent R₄, in the development of very initial model of radiology actor type.

and was not considered representative for the analysis of embodiment of the original modelling language.

Based on theoretical grounds, we expect that a novice modeller may be less prone to retain the two competing levels of conceptualisation in the focus of attention, and probably may have more difficulties switching between levels of reflection of *ML-independent conception of domain* and *ML-mediated conception of domain*. Along the same lines, Wilmont et al. [2010, 2013] explain that the difference between the skills and behaviour of a novice modeller as compared to the expert come from the lesser ability of a novice modeller to maintain executive control over his/her cognitive processes [Wilmont et al., 2010, 2013].

Consequently, we expect that a clear-cut separation between these different levels of reflection in conceptualisation in two distinct steps within a modelling process may be particularly useful for accommodating novice modeller, or in the context of teaching/learning conceptual modelling. This may simply allow for better management of cognitive load, and effective focus on each separate task, namely the primary task of delimiting the domain \mathbf{d} in $\langle mc, O, p, ML \rangle$, and the task of ‘translating’ the conceived domain \mathbf{d} in terms of \mathbf{ML}_{LS}). This, however, remains to be investigated in the further research.

7.4.4 Pragmatic Coherence of \mathbf{ML}_{LS}

Definitional clarity and/or pragmatic coherence. In Section 6.5.1, we acknowledge that the *definitional clarity* of a modelling language may have an impact on the understanding and use of modelling language. However, we refrained from including this dimension in our theoretical framework before further empirical insight into the nature of this influence.

Based on cognitive linguistic grounds, we propose that the clarity as a quality of modelling language definitions does not only relate to the quality of individual construct definitions, but also (and perhaps more importantly) lies in a *clear pragmatic rationale* of the entire conceptual structure. As discussed in Chapter 5, the emergence and structuring of conceptual systems in natural language is tightly related to the use, i.e. conceptual structures are organised and evolve based on pragmatic needs. Furthermore, conceptual systems’ coherence is rooted in their underlying cognitive models. The effect of such an organisation is that human mind understands individual concepts within a given conceptual structure against the conceptual structure as a whole, based on its coherence.

We assume that the same underlying *pragmatic coherence* is naturally sought in using modelling languages in conceptualisation. Based on this insight and empirical evidence, we propose to subsume the clarity dimension under **pragmatic coherence of \mathbf{ML}_{LS}** . We conclude the following:

The lack of pragmatic coherence of \mathbf{ML}_{LS} has a negative effect on understanding conceptual modelling language and on using it in conceptualisation. By increasing the effort required in understanding/using the constructs of conceptual modelling languages, it negatively contributes to the overall linguistic

function cost-effectiveness.

Note that the factor pragmatic coherence of \mathbf{ML}_{LS} is complementary to the dimension of *utility* of \mathbf{ML}_{LS} . The former is concerned with the presence of internal coherence of within the conceptual system/linguistic structure \mathbf{ML}_{LS} and its effect on the ‘understandability’ of a given conceptual structure in general. In turn, the utility regards the adequacy of a \mathbf{ML}_{LS} in relation to the concrete modelling effort.

General-purpose and/or domain-specific modelling language. We expect that the problems with pragmatic coherence of \mathbf{ML}_{LS} are more likely in the case of general-purpose modelling languages. We expect domain-specific modelling languages [Frank, 2013] to be more compact in scope, and more focussed on precise patterns of expression of domains, thus the lack of pragmatic coherence is less likely, though not impossible in their case.

In the case of more general-purpose modelling languages, the lack of (or diminished) pragmatic coherence may be due to the ambition of such language specifications to cover multiple aspects and purposes within some domain of interest, or even to generalise across different domains. A typical consequence of this ambition is that the resulting specification often contains a variety of fine-grained and partially overlapping elaborations of certain constructs (e.g. the number of Event and Gateway constructs in BPMN 2.0 [Recker, 2010]), to allow for various expressions of domain of interest. This may obscure the underlying pragmatic rationale of \mathbf{ML}_{LS} , when for instance the differentiation of these constructs is not clearly justified, as well as when the entire structure is less coherent, etc.

Insights from HEEL field study. We observe that the expert modeller identifies the need for clarifying the rationale of several parts of conceptual structure of ArchiMate. In this context, the most prominent challenges relate to some extent of overlapping between the following language constructs:

- **Actor and Role** – The fact that both Role and Actor can be related to the Business Service in ArchiMate language created confusion about best choice, and led to the experimentation across different model versions until the choices have been made (this can be, for instance, illustrated by Figures 16– 18, which visualises the challenge with this regards in different model versions). The understanding of meta-concepts in this very context was oriented by the major topic to be covered in model, as identified by the modelling team, i.e. the outsourcing of medical services between health sector players. The choices and clarification with the use of Actor vs. Role were oriented by the requirement that contractual relationships with regards to the services delivered have to be clearly expressed and respected.
- **Business Service, Business Process and Business Function** – The reasons for which the use Process vs. Function would be more appropriate

was not considered clear. In addition, both Business Process and Business Function may relate to Business Service, which was considered even more confusing by the modeller.

- **Application Function, Application Service and Application Component** – There are both possibilities for modelling application functionalities, which were considered as not clearly differentiated in the standard.

It should be underlined that these challenges did not regard concept definitions themselves, but more importantly lack of clear distinction how and when to choose one concept over the other. In other words, this concerns the pragmatics of overall conceptual structure, not the individual concept. This can be illustrated in Figures 16– 18: the challenges does not regard a single construct, but the reflection entails portions of conceptual structure of ArchiMate, its logics and meaning of concepts in context, as illustrated in the following citation.

R₁: “I however have the impression that regardless of what we wanted to do, regardless of the way we wanted to structure the concepts, I really think that using a language such as ArchiMate, because of its redundancy (between Function-Process-Service – it is not a total overlap, but still there is a problem of conceptual ambiguity, definitions are really not clear, absolutely not precise), there is a certain complexity that comes from it anyhow... The complexity for me comes from the fact that you can adopt whatever approach, event-driven, process-driven. And, so I think that even if we wanted to structure the domain differently, you would always need using this language (because of this) to define your rules of using the language [...] At one point, it is good that there is this flexibility, that allows to apply whatever modelling approach, but then it requires to define a modelling approach. And honestly, for instance, what you need to use models for, how you are going to structure them, what elements of language you want to use, what are those that you don’t want to use and you restrict not to use, all that.”

(16.03.2016)

7.4.5 Method-like Guidance

In the above-mentioned discussion, the modeller indicates encountered challenges, but also the need to accompany a very general conceptual structure of the modelling language used with some kind of approach or method, which makes explicit (or refines) the pragmatic rationale of conceptual structure entailed.

To be less restrictive with regards to the form of guidance (it may range from a simple legend and documentation to more structured forms, setting

principles, rules and conventions relating to construct use), we will deliberately use the term **method-like guidance**⁶. We hereby assume that an essential role of method-like guidance to language application is to clarify or introduce the *pragmatics* of a given conceptual structure. As of only recently, the research focus in IS/conceptual modelling field switched from modelling methods to modelling languages/modelling notations. In this context, the focus of modelling language research and evaluation has been placed on elaborate, precise and unambiguous definitions of language constructs. However, in situational method engineering field, the importance of pragmatics has already been acknowledged. For instance, already Brinkkemper et al. [1999] claims that besides syntax and semantics, the pragmatics of method chunks should also be considered in their specification. Along these lines, and based on prior reflection, we conclude that:

Method-like guidance that accompanies modelling language in application contributes to making the pragmatic rationale of a conceptual system more explicit. In that sense, it can alleviate negative effect of the lack of pragmatic coherence of ML_{LS} . Therefore, we conclude that the presence of method-like guidance positively affects the cost-effectiveness of the linguistic function.

The *pragmatic coherence* and *method-like guidance* factors are represented as having a joint impact on the cost-effectiveness of linguistic function in Figure 7.10.

General-purpose and/or domain-specific modelling language. We expect that the need for method-like guidance is more prominent beginning from a certain level of comprehensiveness/complexity in modelling languages. This is in line with the finding of Anaby-Tavor et al. [2010]: based on the analysis of conceptual models used in enterprise modelling setting, particularly business analysis, the authors conclude that starting from a certain level of complexity, such as present in multi-view and mutli-diagram models, some kind of documentation and/or method was necessary to ensure effective understanding and use of models. We relate this to the obscured pragmatic rationale of the comprehensive and engineered conceptual structure. Therefore, we conclude that:

The method-like guidance can have a significant influence on language functionality starting from a certain level of modelling language complexity.

Insights from HEEL field study. In the field study observed, this method-like kind of guidance was present in several documents tracing the challenges and decisions by the main observer R₁. This also included several mail exchanges in which the reasons for a particular structuring were explained to a colleague R₃ who was supposed to join the modelling of some parts of the model. An excerpt from the internal document structuring the approach and rules is given

⁶It is likely that different forms in which method-like guidance is presented may demonstrate different effectiveness in fulfilling the goal. However, at our current level of consideration, we refrain from distinguishing the forms in which method-like guidance is offered.

in Figure ?? . Note that, in this document, the rules illustrated refer not only to the individual construct, but put in relation the construct in question with its related constructs within ArchiMate modelling language, and clarify the application. We summarize the combined influence of these factors within the HEEL project in Figure 7.12.

Modeling Approach

Process-oriented: does not work here as we cannot identify the actual patient-oriented processes

Function-oriented: an actor is structured according to functions allocated to roles; the functions and roles have a meaning for all the actors of the domain

Modeling rule #1:

A service is delivered by an actor (physical entity) and has value for the customer (patient)

Modeling rule #2

A service is realised by a set of functions assigned to given roles; the role is defined based on required competences; the function is a behaviour that groups required resources (competences/roles, information, technology, ...)

Modeling rule #3

An economic actor functional structure conforms to a canonical form of an enterprise

Figure 7.11: Excerpt from the internal document on modelling method in the HEEL project, last modification 17.12.2015

7.4.6 Utility of ML_{LS}

We analyse the assessment of utility of ML_{LS} using the introduced dimensions of *conceptual perspective* and *conceptual organisation* of a linguistic structure. As discussed in Section 6.5, we consider that the utility of conceptual perspective lies in its adequacy for *framing the domain* considered in the modelling effort. On the other hand, the utility of conceptual organisation lies in its adequacy for a *detailed conceptual structuring* of the conceived domain.

Insights from HEEL field study. First of all, the empirical evidence provides support for the adequacy of these analytic dimensions in structuring our discussion. The overall evaluation of ML_{LS} utility in terms of analytic dimensions is provided in Figure 7.13.

Conceptual perspective – focus and core concepts. The selection of ArchiMate for the given modelling effort was rooted mainly in the holistic view on enterprise and *core concepts* it provides for modelling enterprises (Section 7.4.1). However, within the process of modelling, the team understood that ArchiMate’s *focus* on IT-intensive enterprises did not well accommodate the focus of domain framing **d** in the concrete modelling effort in the HEEL. Namely, the focus of domain framing in the latter context was decided based on:

- The need to cover the entire health sector at the level of value network/ecosystem,

- The need for asset-oriented modelling of enterprises, which identifies its business capabilities, and relates them to services and resources, which is typical of similar reference-level models across different industries,
- The need to ultimately use the produced models for the risk analysis (purpose **p**).

In this context, ArchiMate was identified as problematic because of its strong *intra-enterprise focus*, and thus lacking of concepts for inter-enterprise modelling:

“I think that, probably ArchiMate can allow for modelling of networks of enterprises, I think it allows it, however at the same time, I agree with [R₂], there is nothing that enables it directly. This concern, you cannot say, ok I have some construct that says this is network, value network...[]... However, I think this is something really important, it is important not only for the model itself, but for what we are going to do with it. To know, for instance, that one [medical] laboratory does [medical analyses] itself or uses other providers, this is something important. I can represent it, but I have the impression that this is hidden, this is not the first-class concept.”

(R₁, 17.11.2014)

In addition, the focus of health sector modelling turned out to require a more *asset-oriented* rather than *layer-oriented* focus on enterprises.

R₁: “I wonder if ArchiMate should be used only for the IT-intensive [organisations], and then I will have the perspective on that IT, which will allow me to connect to a more rich enterprise model [...] I have more a view of service system of [Steven] Alter, where effectively there is a system which delivers services, I see the delivered services [in the reference model], I have activities that use resources, and then I can take different views on [this system], I can take a process view, that does not say that process ‘exist’, in the same sense as my architecture is not something tangible, it is an abstraction of the system. The fact of using layering and relations between as they use it [in ArchiMate], makes you think that you really have....these are different things. The layering [in ArchiMate] is done to break the dependencies, but there are people who understand layering differently. ”

(R₁, 16.13.2016)

Indeed, Service-Capability-Resource focussed was the core of conceptual perspective on the health sector actors (Figures 7.14 and 7.15). Consequently, these three concepts represented the core of sector structuring at this level of

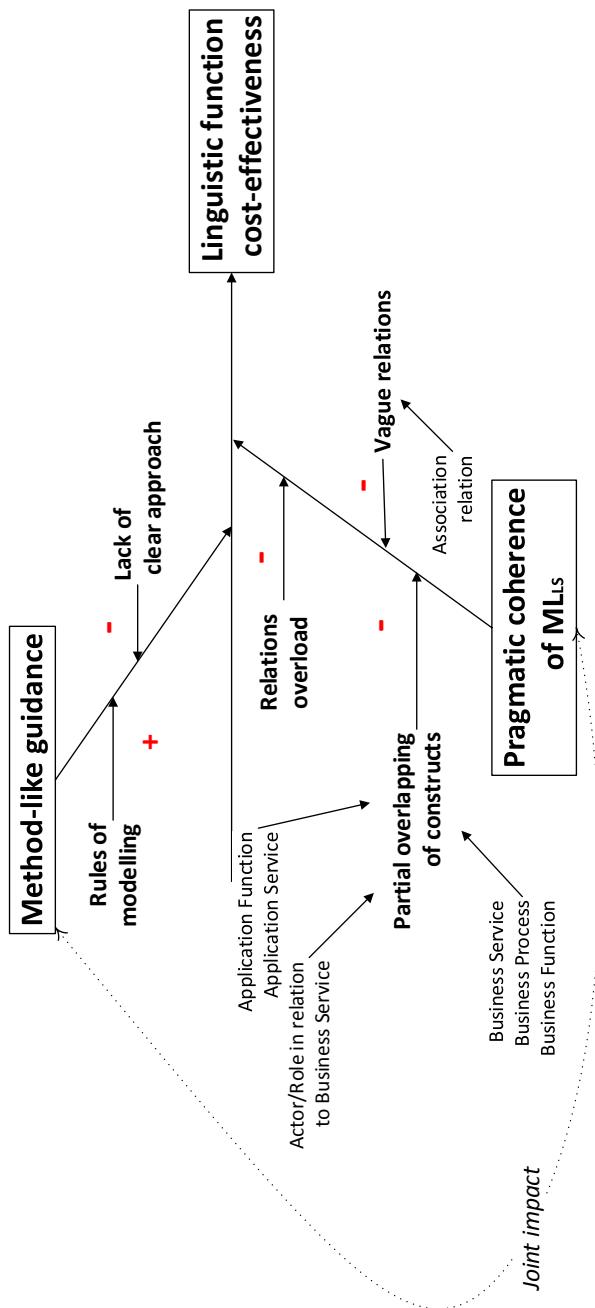


Figure 7.12: Method-like guidance and pragmatic coherence factors in the context of HEEL field study

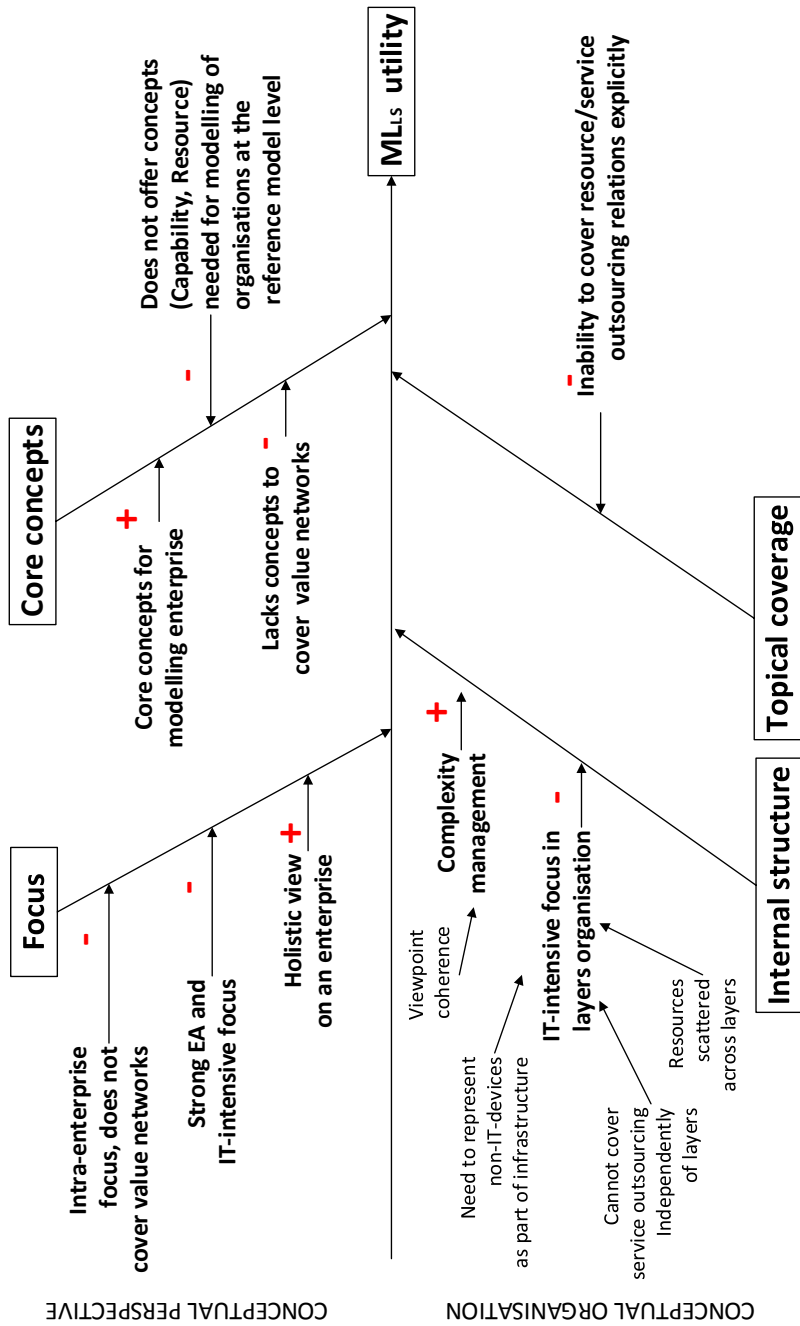


Figure 7.13: The summary of utility of ML_{LS} in the context of HEEL field study, using the analytic framework proposed in Section 6.5.1.

consideration. However, this was only evident by the end of modelling process (see Figures 16–21, in the Appendix ??), once the core structure adopted was clarified and stabilised. Only after this, the modelling language adequacy could be assessed. We interpret this as the consequence of negotiation and alignment between *ML-independent conception of the domain*: it is possible to observe that the respondent R₁ in parallel reflects on how the domain is to be framed, delimited and structured (i.e. *ML-independent conception of the domain*), while in the background there is the questioning of how this domain could be expressed using ArchiMate concepts. With respect to the adopted conceptualisation of the domain, both Capability and Resource were not explicitly present in ArchiMate 2.1 used⁷.

Researcher: “I was wondering whether you would introduce the concept Resource explicitly in the metamodel..because in some of the views, I do not know for which purpose is this view created, but there is Resource (expressed as a Service, using the Service concept), I do not know if it is only for the purpose of illustration, or not... but evidently you are differentiating between the functions and resources....”

R₁: “Yes, but there is nothing in ArchiMate that allows you to say that all of these are resources, ok nothing currently ... in the next version, next year probably they will introduce the Resource and Capability concepts. ”

(15.12.2015)

Conceptual organisation – topical coverage and internal structure. Once the framing of the domain was stabilised, and decided, the service outsourcing was identified as the main challenge to cover in the model (i.e. topical coverage in Figure 7.16 and 7.17). While ArchiMate does embed a service orientation in its modelling framework, the informant R₁ concluded that the EA-like model of layers was not appropriate for modelling of service outsourcing relationships in the context of value network, i.e. health sector. (The interested reader can observe the change in modellers’ reflections with this regard in Figures 16–21, provided in the Appendix ??.) However, the topic of service outsourcing was evaluated as particularly important to cover in the health sector model: in the light of patient information security risk management, where different health actors would exchange patient information through different services offered, it was considered particularly important to be able to consider security risk and related controls.

⁷By the time the project has finished, the Open Group released the new version of ArchiMate specification, v3.0, which adds an additional layer to the modelling language, referred to as *Motivation layer*, and defines both of these concepts.

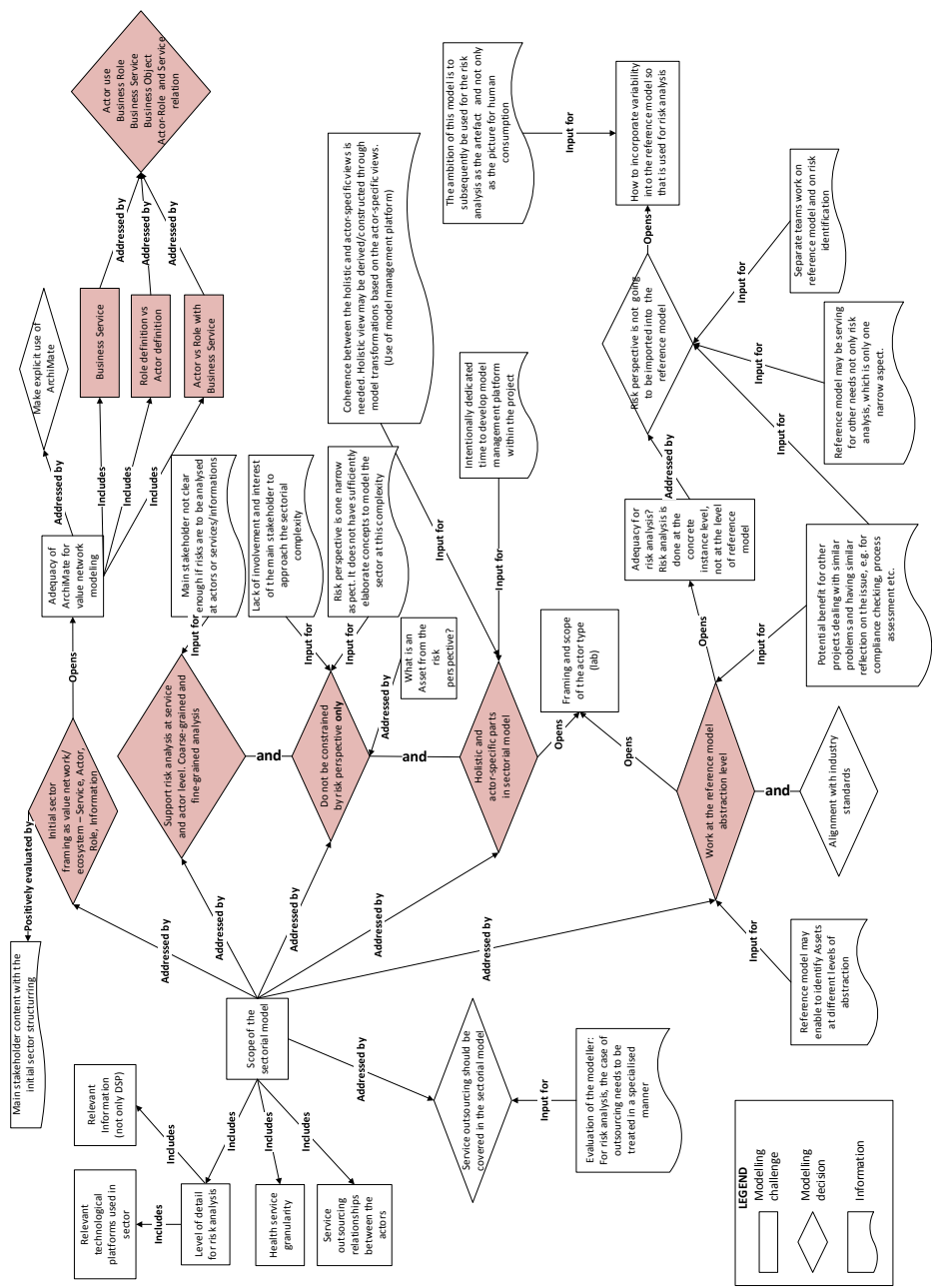


Figure 7.14: The evaluation of MLs utility in HEEL modelling effort, focus on conceptual perspective provided by ArchiMate (highlighted in red) part 1/2

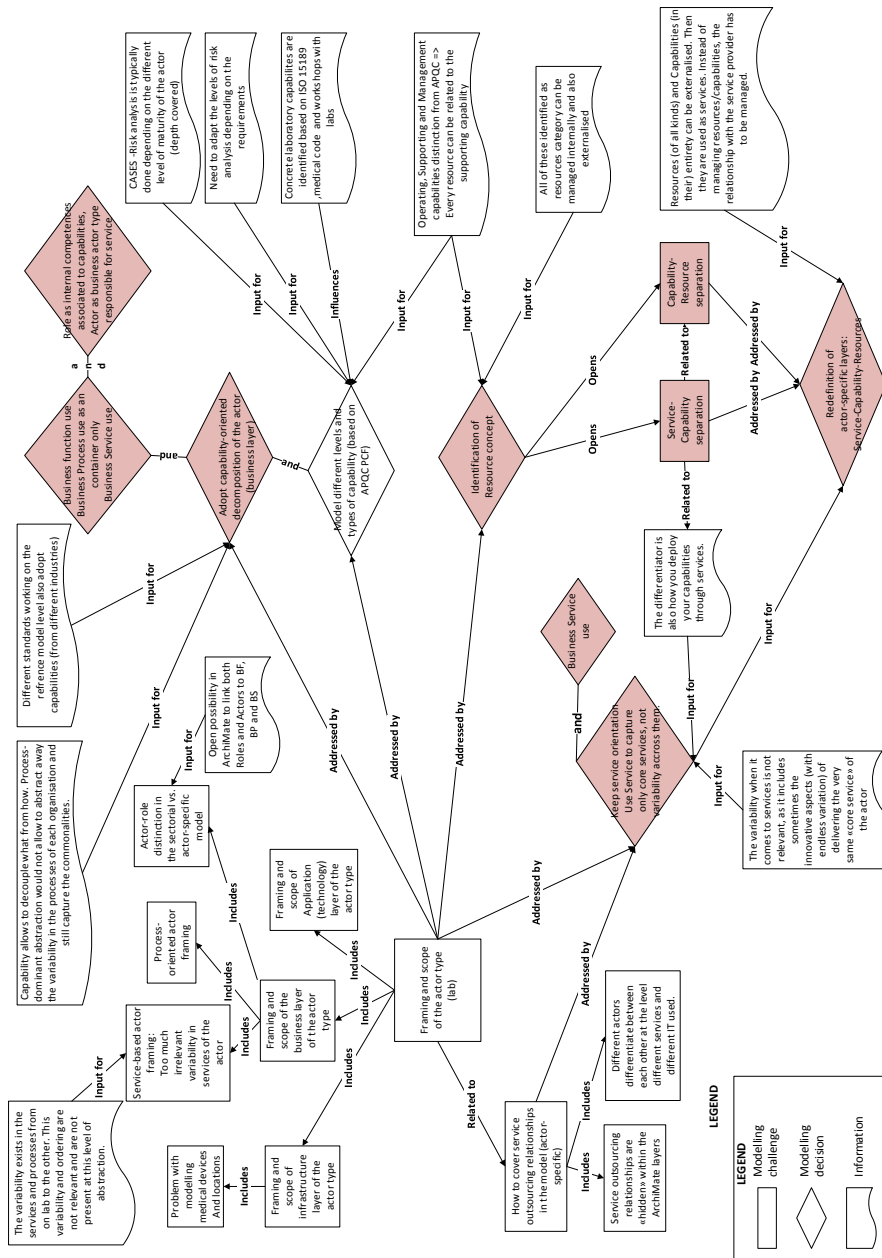


Figure 7.15: The evaluation of **ML_{LS}** utility in HEEL modelling effort, focus on conceptual perspective provided by ArchiMate (highlighted in red) part 2/2

Researcher: “If I understood you correctly, here you have also the preoccupation Actor-ValueNetwork-Service, while in ArchiMate’s philosophy the pre-occupation is what are the key elements for my enterprise architecture...therefore no focus on the relations between the actors in value network.”

R₁: “I have discussed it with Lankhorst in the Open Group, as I reported on our experience in HEEL. [...] The first question is the notion of Capability [...] Then for me there was the question whether ArchiMate lacks concepts for modelling networked enterprises. For him no, as for him ArchiMate can allow it in its framework, and is not only linked to one enterprise, you can well manage the enterprise, as the latter is not just one organisation, it can be one department, networks, etc. So for him there is no need for additional constructs. ”

Researcher: “Does he have experience with it?”

R₁: “That is a bit the question. This is his statement, ok, but we didn’t have time to discuss more [...]. This, for instance, my case, we have come up with RaaS through the project HEEL. We have started with the laboratory [actor modelling], but we have seen that one laboratory may use the services of another laboratory, and I had some kind of [Business] function Outsourcing here [Laboratory Capabilities View], and honestly when you see the model you see this does not make sense, outsourcing you can actually have it all over....”

(01.12.2015)

Researcher: “Here it is getting closer to your reflections regarding the outsourcing of medical services?”

R₁: “Yes, that is it. This is also to show... I am convinced that... I did not see this in ArchiMate, nor for instance in the Bizzdesign tool. [...] They are really strongly related (maybe it is ArchiMate itself) to the layer-oriented architecture, and I think you can find the business elements in all the different layers...therefore, you can construct your viewpoints differently... This I haven’t seen in how they [ArchiMate and Bizzdesign] do it. Effectively, I have reviewed the way I construct the model. Internally, it remains the same thing, there are functions/capabilities (still we debate on it), types of capabilities. It is by offering the capabilities via services that you create value for your client. And, I can start to descend into the ‘layer’ which I call Resources ‘layer’ (and in fact Capabilities define what I do, and Resources layers define how I do that) ...At the level of resources, for every resource I can say either I develop it internally, or I take it from the external actors. For instance, the competencies it is either an employee, or an external consultant, this type of things. Every resource now you can consider (especially with IoT) whether you manage it or you buy its usage, in which case you do not manage it [internally]. Consequently, this has an impact on how you manage the resource, either you manage the resource, or you manage the partner relationship, but not the resource itself. And, so, I have proposed.... ”

Researcher: “For?”

R₁: “For SARiM [another project within the RTO]... to generalise all this under RaaS (Resource as a Service).”

Researcher : “This is getting closer to the management by key capabilities?”

R₁: “I think. And then [...] this implies that the relation between provider and the supplier can be quite hidden in your architecture, and this for the moment, I find that the tools À la Bizzdesign they do not allow it... This reasoning I think it is interesting to, if not infer it, then to deduct it from the complex model, like this one. Here I can say, I have the infrastructure, but I do not use the infrastructure, I use the cloud xyz, and then I can reconstruct my view network of actors by analysing these models [per each individual actor].”

(01.12.2015)

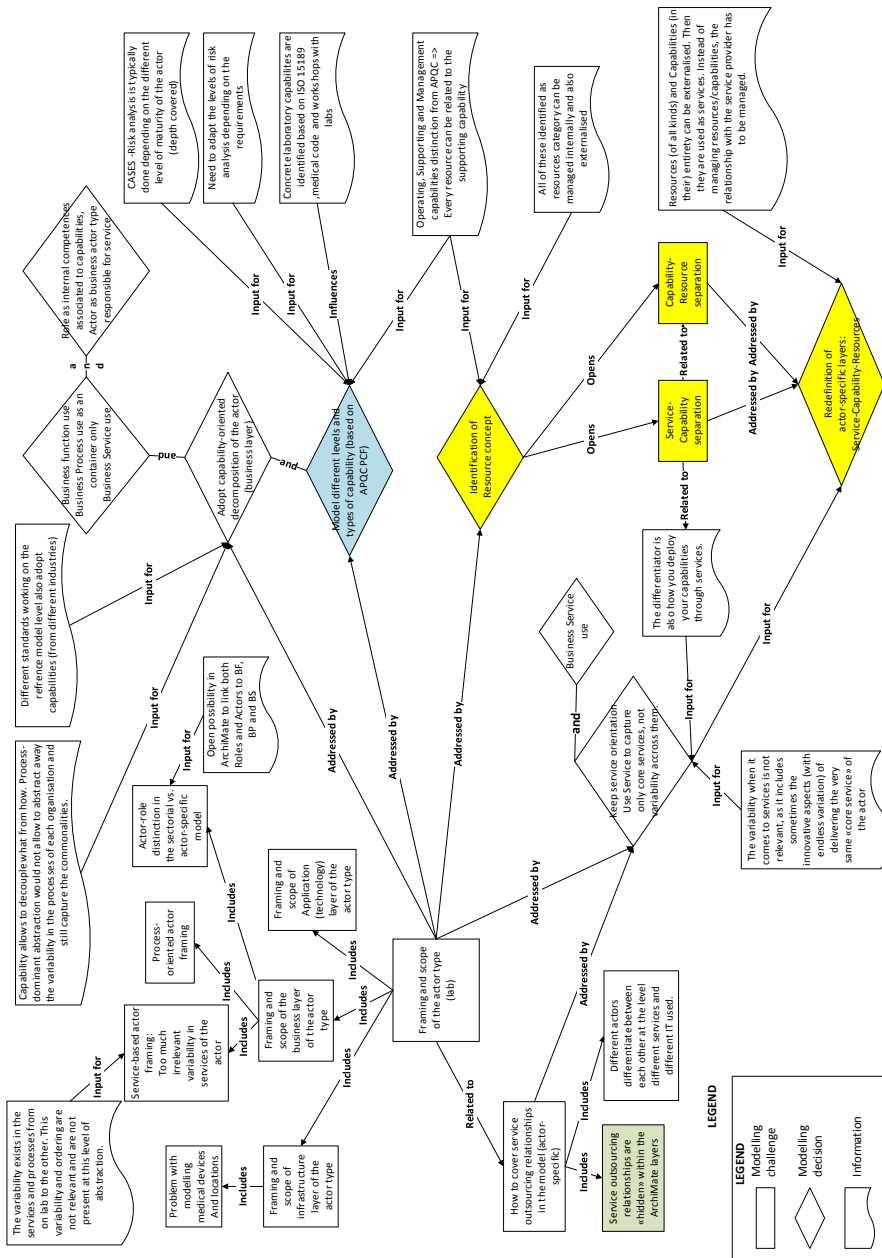


Figure 7.17: The evaluation of ML_{LS} utility in HEEL modelling effort, focus on conceptual organisation provided by ArchiMate, part 2/2. Elements pertaining to topical coverage are highlighted in blue colour, to granularity in green colour, and internal structure of ArchiMate in yellow.

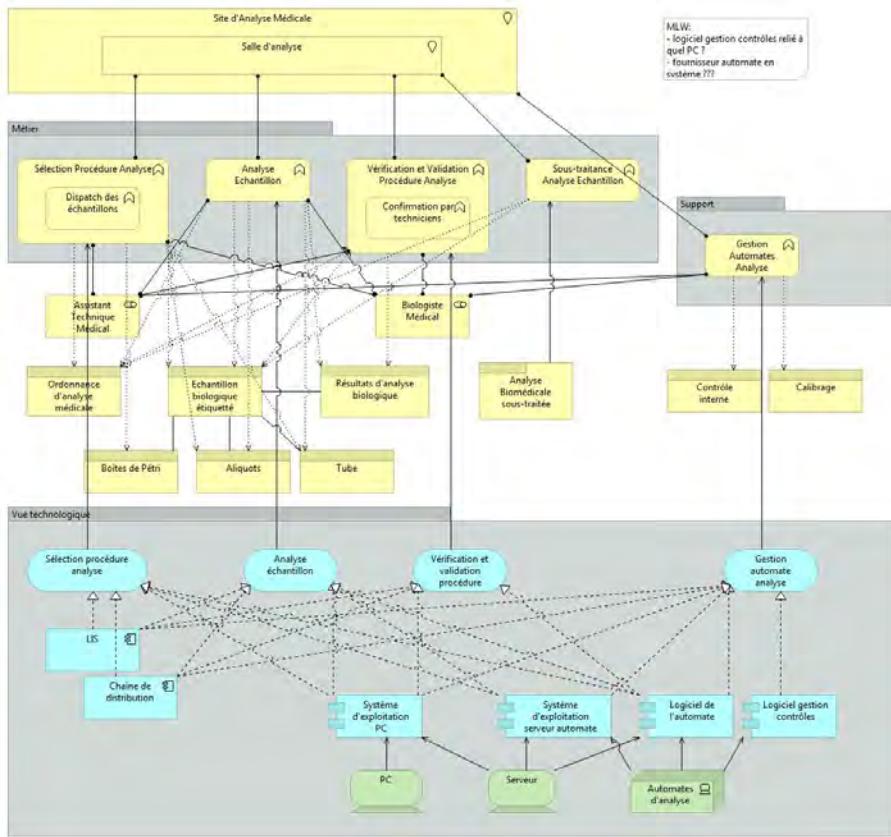


Figure 7.18: Lab actor: Analysis Capability View

7.4.7 Language Adaptation

Insights from HEEL field study. In the HEEL field study, we observe that the main cause of language variant emergence related to the major problems of utility with the used linguistic structure with respect to expressing relevant ‘aspects’ of the domain, as discussed in Section 7.4.6. With respect to these discussions, we identify the major challenges in terms of *conceptual perspective* of ArchiMate. The main modeller concluded that *ML-independent conception of the domain* required quite different conceptual perspective than the one offered in ArchiMate: its *focus* was more asset-oriented, while the *core concepts* required were lacking in ArchiMate. The resolution of these challenges implied the need for a re-structuring of core *conceptual perspective* of ArchiMate, to accommodate the shortcomings identified. Note that the language variant emerged in parallel with the very process of modelling, therefore the link between model and meta-model level artefacts was not made explicit.

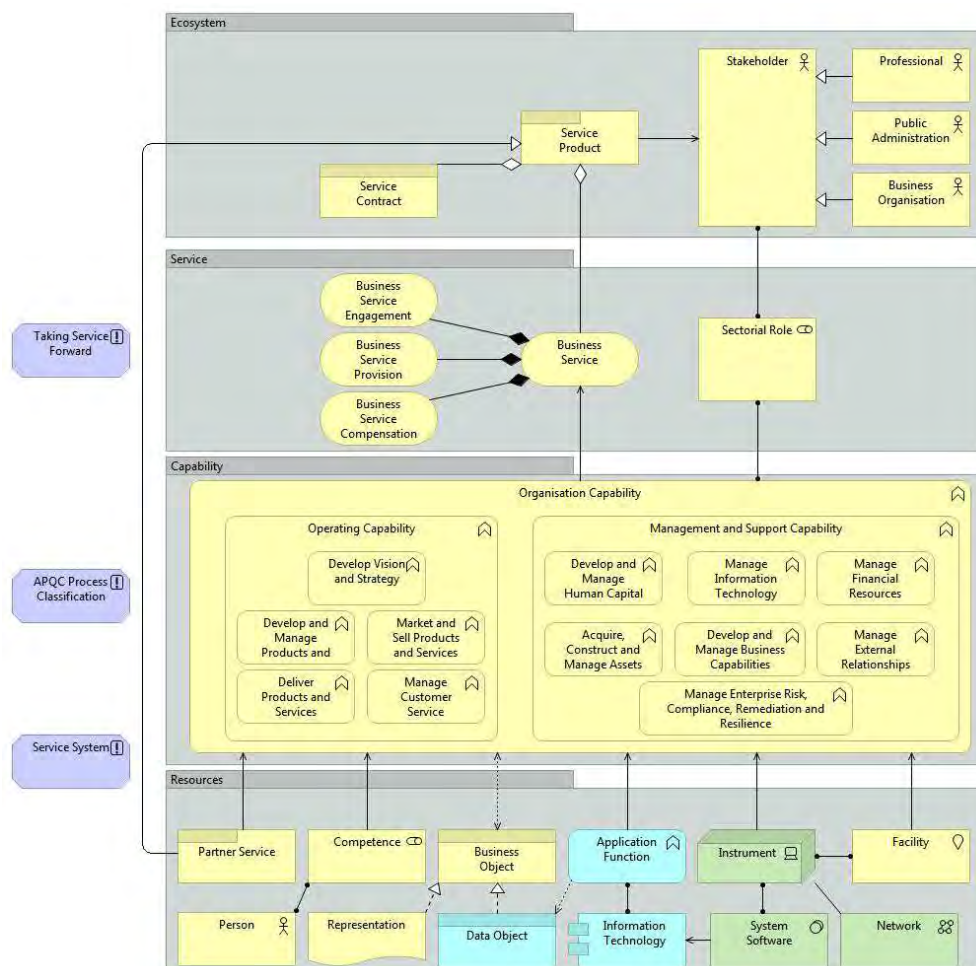


Figure 7.19: The overall organisation of the ArchiMate-based language variant in the HEEL project, reflecting the core concepts and structuring of the business reference model. Packages indicate the re-interpretation of layers as different perspectives on the same ecosystem.

The diagrams in Figures 7.19– 7.22 are part of the ArchiMate metamodel adaption, referred to as (health) *Sectorial metamodel*, while several views from the model developed in accordance with this ‘logics’ are illustrated in Figures 7.23 and 7.18. Figure 7.19 shows the overall logics applied in re-structuring ArchiMate to meet the identified needs. This adaptation removes the layering as the core element of language (other than preserving the colours associated to different layers in visual symbols). Here Package is used to identify different viewpoints/perspectives that may be taken on the health sector, also in dependence on the level of risk analysis that may be needed. The notion of Resource identified as missing (Section 7.4.6) is *implicitly* introduced through grouping of concepts into the package named Resource. As previously discussed

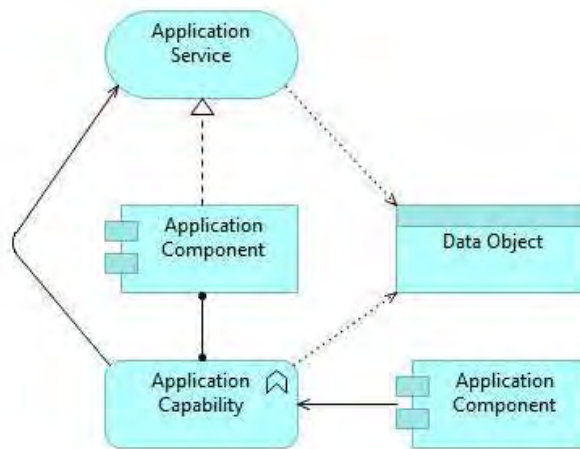


Figure 7.20: The specific view on the ArchiMate-based language variant in the HEEL project, focussing on modelling of applications in the reference model.

in Section 7.4.6, the explicit resource concept was considered as necessary for covering service outsourcing. In this context, the layered framework (internal structure of ArchiMate) was a source of problems for the main modeller.

Figure 7.20 captures the principle of modelling software applications, taking into account the following:

R₁: “We had first Application Function, then Application Service, and again Application Function [across different model versions]. I think that finally Application Service is interesting to keep if I consider that the service may be internal or externalised. [...] I would model in terms of Application Function offered by an Application Component, and then these functionalities [Application Component] are exploited through services. Why, if we could go directly to the functionalities? This allows me to say that maybe I want to buy that service, rather than develop it internally....It [The use Application Service this way] is more something like an interface, more than anything else.”

(15.12.2015)

Additionally, Figures 7.21 and 7.22 focus on two viewpoints, oriented on modelling capability of an actor, and sector-level viewpoint that focuses on exchanges of services between actors. These viewpoints are used as organising principles for views in models developed. For the sake of illustration,

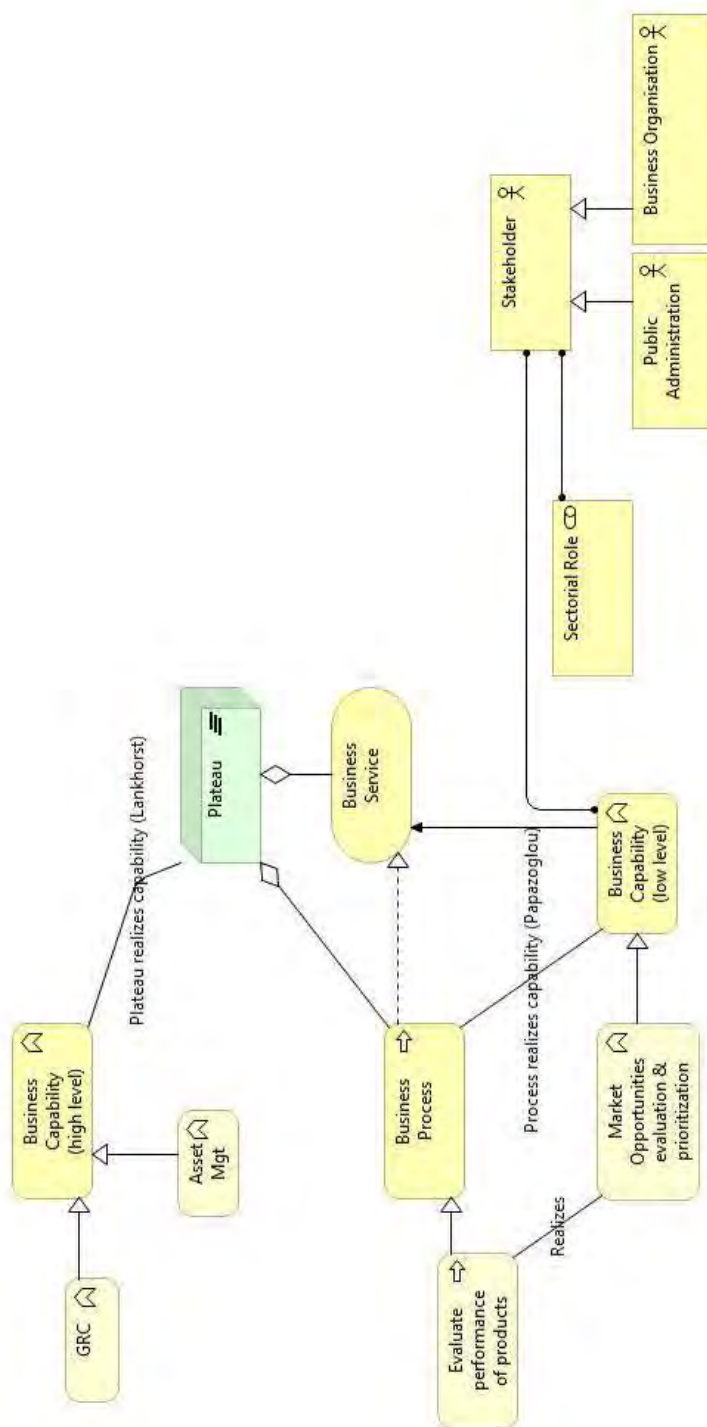


Figure 7.21: Capability Modelling

Figures 7.23 and 7.18 provide the excerpts of ArchiMate-based models which reflect the conceptual structure redefined in the concrete modelling effort.

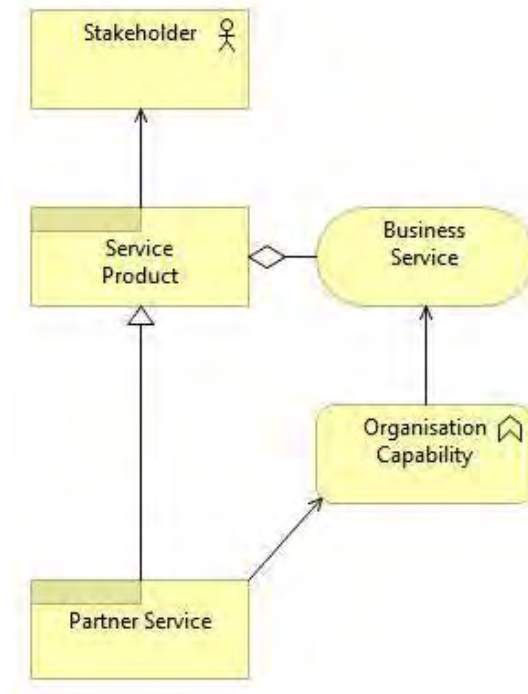


Figure 7.22: The specific view on the ArchiMate-based language variant in the HEEL project, focussing on ecosystem perspective in the reference model.

Intervening factors. In HEEL field study, we observe that the desire to apply the same pattern of thinking about sector and service outsourcing to another similar projects – therefore to *capitalise on the knowledge gained* through the modelling experience fostered the decisions to invest effort in adapting the ArchiMate language. This regards the core of a new conceptual perspective that emerged, reflected in domain structuring in terms of Service-Capability-Resource core concepts, as illustrated in Figure ???. Indeed, the applying of this emerging structuring has driven the main informant to continue deepening the understanding of problem at hand, but also to start clarifying the use of ArchiMate. However, despite this ambition of *knowledge capitalisation*, the *resource availability* and the lack of appropriate *modelling infrastructure* to support the explicit language adaptation, lead to the decision to keep the language variant in an *implicit form*. Concretely, the ArchiMate-based language variant is developed as a separate model, expressed in ArchiMate language, and was used as a guidance to the modelling team in their process of modelling. ArchiMate’s model editor Archi is used as an environment to create ArchiMate models, and these were imported into MONET platform to be related with

the risk models. The integration between ArchiMate and risk models is performed having in mind the metamodel variant and a modified interpretation of ArchiMate constructs. The reflection of trade-offs of such decisions by the main informant is illustrated in the following:

R₁: “If we want to do things properly, then either we have to specialise the language to introduce the concepts and relations that we allow, or we have a problem. Because we said this is how we work, but there is nothing that really constrains [the use of ArchiMate]”.

Researcher: “Nothing that implements it? ”

R₁: “Yes. This means that we continue to use ArchiMate models expressed in purely ArchiMate constructs, therefore we still use the constructs of ArchiMate, I use the concept Business Function, but I have to understand that this is a Capability. I can use prototypes, but this is very heavy mechanism.... Another question is: if I have to specialise the language, what then is the interest [of using it in the first place]? It is just better rather than implementing from zero, this is a bit of a problem. We do not have the meta-modelling environment, therefore we continue to use the existing languages.”

(17.03.2016.)

7.5 Reflection: Language Use, Adaptation and Abuse

In the following, we reflect on the findings from the field study in light of understanding and characterising language use.

In the HEEL field study, ArchiMate as a modelling language was selected based on the assessment of core concepts offered by the language, which were somewhat generic for any enterprise modelling effort (e.g. Actor, Business Activity, Business Service, Software Application, etc.) and its holistic perspective on the enterprise. The reuse of an existing and already known standard modelling language, and an available (open source) modelling tool, was also assessed as resource-saving. Another aspect of ArchiMate was also considered important for modellers, that of viewpoint framework (Section 7.4.1).

However, after the challenges faced in applying ArchiMate, one can debate whether the initially selected modelling language is *abused*, i.e. if its usage is forced outside of the designated ‘competence area’ which is enterprise architecture. This is also reflected in the following reflection of the modeller:

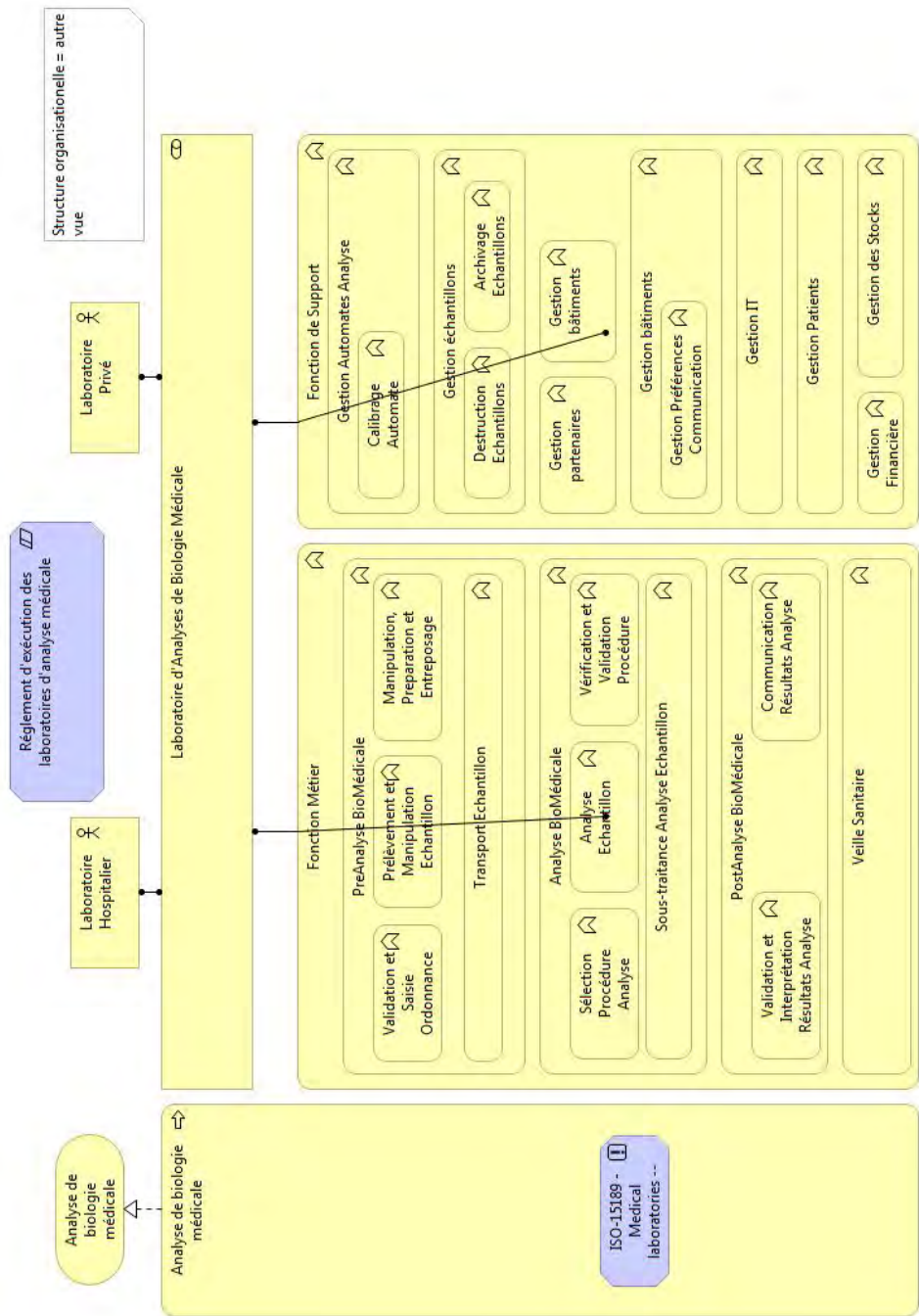


Figure 7.23: Lab actor: Capabilities view

R₁: “What I can say now, it is that I found ArchiMate to be of interest at the beginning of the project, for the numerous reasons that you have already understood. The language exists, you do not need to start from scratch, in any case we were not forced to start with a heavy phase...Finally, we have done it [language adaptation] in an iterative manner, while being able to continue [to model the problem]..... The limits, it is only now that I see them.

[..]

Another question is: if I have to specialise the language, what then is the interest [of using it in the first place]? It is just better rather than implementing from zero, this is a bit of a problem. We do not have the meta-modelling environment, therefore we continue to use the existing languages.”

(16.03.2016)

While ArchiMate was a priori assessed as being useful in terms of *conceptual perspective* level, the implications of ArchiMate’s conceptual perspective turned out not to be fully understood. The problems with EA dominant perspective, as well as the focus on IT-intensive enterprises within ArchiMate surfaced in the modelling process, when trying to apply it to modelling of a value network of the health sector reference model. In working out the solutions to the challenges met, the modelling team finally created a new way of thinking, i.e. a new *conceptual perspective*, which diverges from the original ArchiMate, while it still reuses most core concepts of ArchiMate.

The realisation that ArchiMate was not probably the ideal choice was also mentioned by the main informant, however not much other option was available instead of its reuse:

R₁: “...We however started from ArchiMate core concepts, those for enterprise modelling. I think we gained a lot at the start, because it is an existing language we adopted, there was no learning curve involved, there was no huge language definition phase... Now, I am at the point where I ask myself what it still contributes... ”

(28.04.2015)

R₁: “The question I ask myself, to come back to the selection of ArchiMate. I am not sure I would have made this choice, had I had the option.”

Researcher: “Yes, what would you have taken?”

R₁: “ Anything, even the Excel sheet. The most important thing is that finally the meta-model is defined and whether it is based on ER or ArchiMate, it does not matter....Finally, we define our own meta-model, and I see less and less reason to express it in ArchiMate. I lose at that point some richness, because I put myself an additional constraint ... the only reason I still see to use the language is the model editor. But, if it is only for us [cf. the use and development of models], then we will develop our little interface which will allow us to do as EMF [Eclipse modelling framework], to add a new class, etc.

Another question is: if I have to specialise the language, what then is the interest [of using it in the first place]? It is just better rather than implementing from zero, this is a bit of a problem. We do not have the meta-modelling environment, therefore we continue to use the existing languages.”

(01.12.2015)

Therefore, we can observe that the selected modelling language was clearly applied outside of its primary competence area. We suggest that the inappropriate language may have also been chosen, not only due to the fact that there was no other alternative then to define a new language from scratch, but also because of the modelling tool availability (factor modelling infrastructure) coming with the existing language.

R₁: “...there is a model editor. ... The problem is – it is not complex to redefine the metamodel of ArchiMate, but the problem is that such a redefined metamodel needs to be implemented, and all the relations constrained in the appropriate way. ”

(28.04.2015)

Reflecting on this experience, we suggest that the clear pragmatic rationale and structural coherence within the linguistic structure of a modelling language have an important impact on understanding and use of the language ‘competence area’.

In the context of ArchiMate’s application within the field study, it is not only the reuse of core concepts that allows to assess the ArchiMate’s adequacy. Besides the core concepts of EA/EM, the conceptual perspective of ArchiMate

is also defined by the focus it has comes with a specific orientation on covering the layers of EA, and the interdependencies present across these layers. As can be observed, outside of primarily EA-focus, the adequacy of the layering can be questioned. In that sense, ArchiMate language, although presented more and more as a general-purpose EM language is not necessarily such a language. The detailed conceptual organisation is oriented by the EA focus.

To this end, we observed that the dimensions of *conceptual perspective* and *conceptual organisation* dimension offer a preliminary principle for characterising the modelling language variants. Namely, there is a fundamental difference between two kinds of modelling language adaptations.

On the one hand, when the variant of original modelling language only to some extent modifies the *conceptual organisation* within a modelling language *while staying within the frame of same conceptual perspective*, we can talk about something which in natural languages is refer to as ‘dialect’. More precisely, a conceptual modelling language might better be understood if equated with any (coherent) conceptual system in a natural language, both structurally and functionally. From this point of view, we can then consider all these variations as providing different levels of content and structural refinement (i.e. conceptual organisation dimension), while staying within the same core structure of some domain of interest. This phenomena can be understood and explained in terms of Lakoff’s interpretation of conceptual system variation, and its relation to the notion of weak linguistic relativity (Section 5.3.3): from the more cognitive-linguistic perspective, the main difference is in slightly different conceptual organisation and use of concepts to frame alike domains of experiences. Nonetheless, in this case, the adaptations still stay within the same basic level of thinking, reified in the same core concepts. Therefore, using the dimensions of our analytic framework (Section 6.5.1), we suggest that the main difference between the original modelling language and its adaptation in this context can be found in different granularity, potentially slightly different concept interpretations (e.g. concept refinement or restriction), potentially differently organised concepts, and different topical coverage required by the modelling language variant. Take, for instance, different variants of BPMN process-modelling languages [Braun and Esswein, 2014]: while these are tuned towards different needs, their framing of processes stays within the same core structuring of process models.

However, if the emergent modelling language variant moves out of the framing of domain defined within the *conceptual perspective* of the original modelling language, this clearly reflects the shift in terms of taking a different lens on the ‘world’, implying different focus, and thus different core concepts used to provide core structure of the domain of interest. While such variant may still have some level of overlapping with the original modelling language, we still argue that we should speak of a different conceptual system and different domain of interest, i.e. ‘new’ modelling language.

This brings us to the three possible dimensions along which a conceptual modelling language may be adapted. While in the previous discussion, the conceptual-level adaptations of modelling language (focussed on linguistic function) are in focus, one may also add the possible ‘notational’ variants (in

the sense of visual notation, e.g. tuned towards different classes of audiences) as well as different ‘syntactic-semantic’ variants (focussed on representational function), depending on the mechanical manipulations needs.

However, while the latter two dimensions may be considered as (context- and) purpose-specific or topic-specific refinements of the modelling language, the modification of conceptual perspective results in changing the core way of thinking about the domain of interest, potentially resulting not only in different conceptual structure within the domain, but also in different delimitation of the relevant domain of interest. The latter modifications to the conceptual perspective, such as the one observable in the HEEL field study, imply the creation of a new way of thinking, i.e. of a fundamentally different conceptual system and resulting conceptualisation of the ‘world’. In terms of modelling language, then, we can speak of a different modelling language, rather than a dialect-like modification of the original modelling language.

7.6 Summary

This section discussed the propositions of our explanatory theory, and findings of our interpretive field study. To this end, we discussed in more details the role of interpretive field study with respect to theoretical development, as well as the methodical details of field study realisation. Thereafter, the detailed findings are discussed, along with the specific insights from the performed field study. The resulting explanatory theory proposes that primary factors shaping enterprise modelling language use relate to its cost-effective functioning in terms of linguistic and representational function. Other factors such as e.g. available modelling infrastructure, ambition of knowledge capitalisation, political factor and resource availability may attenuate these primary factors. With respect to linguistic function, we observe that, unlike the wide-spread assumption in our field, the linguistic framing of domain imposed by modelling language is not automatic, but that a continuous interaction between (what one can refer to as) a pre-existent/default conceptualisation of a domain and the modelling language-biased framing of the domain. In this process, factors such as functional embodiment of the conceptual structure, its utility with regards to modelling context, but equally its pragmatic coherence, and existence of the method that guides the use of language have an effect on the success of linguistic function. More specifically, pragmatic coherence and clear pragmatic rationale underlying conceptual structure seem to be more prominent as factor than purely the clarity of individual construct definitions. The lack of such pragmatic coherence hinders the understanding, acquisition and use of conceptual structure, while the presence of some form of method-like guidance may attenuate this negative effect. Finally, our findings also suggest that a clear pragmatic rationale and structural coherence of a linguistic structure of modelling language may be an important to clarify the competence area of a modelling language, and thus head on avoid its use outside of the intended application.

CHAPTER 8

Discussion

In this chapter, we discuss how the challenges relative to the validity of our findings are addressed, as well as reflect on the limitations of the conducted research (Section 8.1). Thereafter, in Section 8.2, we discuss the implications of our results towards further theoretical development and language engineering.

8.1 Validity Threats and Measures

Broadly speaking validity refers to the trustworthiness of research results. In the following, our discussion of validity is organised in terms of a commonly used classification of *construct validity*, *conclusion validity*, *internal validity*, and *external validity*. We approach this discussion by taking into account the peculiarities of interpretive research [Klein and Myers, 1999] in general, as well as the specific role of interpretive field study in the explanatory theory development (Section 2.3.2).

8.1.1 Construct Validity

Construct validity is usually discussed in terms of the extent in which “*operational measures that are studied really represent what the researcher has in mind and what is investigated according to the research questions*” [Runeson and Höst, 2008, p. 71]. Essentially, this aspect of validity refers to how the empirical observations and theoretical constructs match.

In the context of interpretive research, theoretical constructs are typically used as a framework of interpretation of the observed phenomena. However, theoretical constructs typically are not held firm, instead their refinement is informed by contextualised ‘application’ of constructs to understand/explain the observed phenomena. Therefore, to strengthen this dimension of validity,

it is essential to ensure the quality of interpretation. More specifically, the researcher should explicitly reflect on how theoretical constructs are contextualised within the field study (the principle of contextualisation [Klein and Myers, 1999]), as well as how his/her interpretations interact with, are revised and refined throughout the empirical observation (principle of dialogical reasoning [Klein and Myers, 1999]). To this end, in developing the explanatory theory, we applied several measures to mitigate risks related to this aspect of validity, and enhance the quality of interpretations.

Field study design. First of all, these measures concern the choices taken in shaping the interpretive field study. We opted for an in-depth character of the field study (Section 7.2), as well as a relatively long observation period (Section 7.2.2), in order to allow time and space for the revision and refinement of our interpretations. This process was largely supported by the iterative-incremental nature of qualitative data analysis [Miles and Huberman, 1994] which we followed (Section 7.2.4).

Analytic instruments. Throughout the analysis process, we implemented the following measures. *First*, largely in accordance with the suggestions of [Miles and Huberman, 1994], each analytic instrument used contained an explicit space (e.g. section or column in the document) intended for writing down comments and reflections on data collected and analysed. Some examples of analytic instruments in Appendix 9.5 illustrate how these fields are used in our research process. *Secondly*, the coding system was not held firm, but flexible and dynamic: it was reconfigured and evolved throughout the analysis, with new reflections, variables and conclusions emerging. The ‘snapshot’ of the full coding system at different analytic stages can be found in Appendix 9.5, illustrating the effect of analytic progress on the evolution of codes, i.e. our interpretation of the match between theoretical constructs and field study events. *Next*, we have also used memoing as a means to keep trace of reflections such as our doubts, open questions, need for clarification of (our understanding of) certain aspects in the field study, etc. Memos have then been integral part of the analysis.

Moving target. One of the major challenges in interpretive research is the fact that a researcher has to deal with “a moving target” [Klein and Myers, 1999]: understanding that the phenomena observed is not static in nature, but unravel and change in front of the researcher’s eyes. In that sense, studying the relationships between individuals, organisations and technological artefacts cannot be approached as if these were fixed and given, but they have to be studied and uncovered by appreciating that these are made sense of in the interaction with social, cultural and historical context in which the phenomena occur.

The core of our proposal of studying the use of enterprise modelling languages indeed is based on this assumption. While our fundamental view on modelling (Chapter 4) and on conceptual modelling languages (Chapter 6) allow for explicitly considering the context of modelling, in explanatory theory

development, we had to make sure that the field study context and its influences are appropriately captured and understood. The fact that the researcher and the project team have shared organisational background, as well as the fact that there was an established relation of trust and openness in interactions between the researcher and the entire project team (here specifically the main informant) enhanced the understanding of local context, and supported researcher in refining both theoretical constructs and their ‘contextualisation’ in the field study.

More specifically, regarding the moving target challenge in the realised interpretive field study, we made sure to ensure to capture, analyse and discuss with the informants their feedback regarding modelling language used at different points of time in the modelling effort. For that purpose, we analysed the factors selection of the modelling language at the very beginning of the project, and observed how these evolved during the entire modelling progress. Namely, we tracked the progress of modelling, modelling language-related reflections, and confronted informants with specific language-related challenges and decisions taken, seeking for their further understanding and explanation. Lastly, we also realised a post-festum discussion with the main informant in the field study. Namely, at a point of time when the project had already finished, we invited the main informant to look back, reflect and discuss together about the language selection, lessons learnt, challenges encountered and decisions taken with regards to the modelling language use. In this specific point of time, we made sure to confront the past interpretations with the eventually contradicting new ones, and to seek for further clarification from the main informant, or from the available documents.

8.1.2 Conclusion Validity

Conclusion validity refers to the quality of researcher conclusions, in particular when it comes to carefully attending to the effect of *researcher's bias*. In the context of interpretive research, however, the researcher's bias is considered as a starting point of theoretical understanding, and instead of trying to eradicate it, this aspect of validity is more concerned with maintaining the explicit awareness of these preconceptions, and being as transparent as possible about how these pre-conceptions affect the research process and conclusions [Klein and Myers, 1999].

Research approach choices. *First and foremost*, we consider the choices taken with respect to the philosophical stance and research approach, as part of our bias which orients the study of selected research topic. Therefore, our methodological choices have been explicitly discussed and justified. Although this kind of bias is unavoidable, its explicit consideration allows for a better understanding of the conducted research process and contributions by an interested reader.

Next, in the interpretive field study (Section 7.2), our theoretical constructs are imported with an explicit awareness that they represented the source of bias, which should be confronted, (dis)confirmed and/or refined through empirical

observation. Consequently, the entire process of qualitative data analysis is performed by remaining – to the best of our ability – sceptical about theoretical constructs imported, and being attentive to premature closure in our conclusions.

Triangulation. Additionally, we use *triangulation* as a means to strengthen the quality of our conclusions (Section 7.2.3). We gather different perspectives on the phenomena observed, based on the feedback from informants of different background and with different roles in the modelling effort. These perspectives of the informants are triangulated with data obtained from project documentation, email communication, and project meetings. Since the researcher was granted the access to the entire project material on the file server, cross-checking the consistency between informants' input and written sources of information was largely facilitated.

Interview design. In gathering data from our informants, the very format of *semi-structured interviews* is intentionally chosen to allow ample space for the informants to bring forward topics they may consider relevant, to offer alternative interpretations of events, motives for modelling decisions, which may not fit researcher's emerging understanding. We re-listened and re-read the transcriptions of interviews at different stages of analysis process, in order to 'catch' and reflect on this kind of input by the informants. In this context, the professional history shared between the researcher and field study informants has greatly facilitated open discussions, and allowed for sharing all the reflections modeller had about the project, modelling effort, and modelling language used.

Neutral colleague. In addition, at several instances, we have used the tactics of discussing with neutral colleague, to help us be confronted with our imported biases, to prompt for alternative interpretations, etc. This was even more important, as in verifying our interpretations, we mostly relied on the discussions with the main informant. While the 'neutrality' of any third party can be challenged, we found this very process valuable in that it forces the researcher to take a broader and less-engaged consideration of the course of the field study events, and hence increases the chances to identify/be prompted for the lack of clarity in the conclusions and assumptions.

Transparency. One of the measures to mitigate the risks with respect to conclusion validity is to ensure traceability and transparency in the analysis. Besides explicitly discussing and justifying the ontological and epistemological positions adopted in relation to the research subject, as well as the configuration of research approach, we also implemented measures to make the process of data analysis as explicit and transparent as possible. These measures are intended to, on the one hand, allow for inspection by a third party, but more importantly serve as support to the researcher for reflecting on imported biases, i.e. we used these tools as a means to revise and reconsider all the reflections and basis for the conclusions drawn.

More concretely, in explanatory theory development, each new data collection and analysis iteration prompts the researcher to reflect on several levels, i.e. the understanding of events and process within the field study, the coding system, the elements of theory. We used memoing (within nVivo software) to note down doubts, ideas, emerging links between theoretical constructs, events in the field study, etc. These memos are dated, coded, and used as integral part of the analysis. Furthermore, each analysis instrument used had the special section that allows space for researcher's comment, again in order to note down and trace our own doubts, reflections, questions, changing interpretations, areas and variables requiring more attention, etc. For instance, each model version summary (Appendix 9.5), or data display used (Appendix ??) contain such sections. Lastly, the coding list had a separate code to single out surprises and specific notes, as they appear in the analysis process by the researcher (Appendix 9.5 and 9.5). We also kept record of different coding system versions, as well as the versions of analysis instruments used.

Last but not least, we did our best to ensure quality documentation of the research process. Some of that material is available in the Appendix 9.5, while specific source data, interview transcripts, and final versions of analysed data may be made available upon request.

8.1.3 Internal Validity

According to [Miles and Huberman, 1994], internal validity refers to the quality of relationships between the variables. In the context of an explanatory theory, it is specifically concerned with the extent to which a researcher attends to the possibility that investigated effects may be caused by a third factor, i.e. mediating variables.

While in the thesis we work towards an explanatory theory, we subscribe to the understanding of causality discussed in [Miles and Huberman, 1994]: the causality within studies of human behaviour is inherently local, and tied to the complex of interacting factors, which often combine, affect each other, and create effects. Therefore, the causal relationships between variables have to be assessed retrospectively, and based on temporality, plausibility, strength of association between the variables, etc. "Even the most elegant quantitative procedures, at bottom, deal with associations, not really causes. They can only develop plausible possibilities "smoothed" across many persons and situations" [Miles and Huberman, 1994, p. 147].

We identify the factors that affect the use of modelling languages in an enterprise modelling context (Section 7.3), and in particular those which affect the cost-effectiveness of linguistic function of the modelling language. As discussed in Section 7.3, the empirical support for all the identified dimensions is not provided in the performed field study. This is also logical, as the appearance of individual factors is expectedly largely context-dependent. Therefore, our explanation of the variables affecting the use of modelling language in its linguistic function, though theoretically grounded, is not exhaustive, and the appearance and influence of identified factors should be further analysed across different contexts and configurations to strengthen the quality of our

conclusions.

Secondly, besides the main factors derived in the fundamental view on conceptual modelling language (Chapter 6), our empirical insight suggests that *method-like guidance* acts as a mediating factor on language use. Namely, the presence of method-like guidance to the use of modelling language has a positive effect on the overall linguistic function cost-effectiveness, while its lack may have an important negative influence, starting from a certain level of comprehensiveness of modelling language used. Further research is expected to allow for more detailed understanding of the nature of this influence.

In the explanatory theory, we suggest that the decreased cost-effectiveness of the *linguistic function* has a major *influence* on the decision to adapt modelling language used. However, we do not claim that this factor is the *only cause* of modelling language adaptation. More concretely, within the realised field study, we identify that other factors such as organisation learning (desire to capitalise on the way of thinking on other projects of the similar complexity and facing similar challenges) influenced and catalysed the decision to start explicitly making the metamodel adaptations early on in the modelling effort. These factors can go beyond the concrete modelling effort observed, as is the case with the factor of organisational learning. While this does not necessarily mean that, without these enhancing factors, the modelling language adaptation would not have happened, their presence fostered the decision to restrict and specialise the ArchiMate language more explicitly.

Nevertheless, at a higher level of considerations, the theoretical constructs we developed as the basis for the explanatory theory demonstrated their analytic adequacy within the field study. This specifically regards the dimensions of analysis of linguistic functioning of the conceptual modelling language, as grounded in cognitive-linguistic theories. In that sense, we are confident with regards to the preliminary evaluation of the proposed “sensitizing device” and believe that its further elaboration is promising. We expect that this further elaboration will give the opportunity to elaborate the relationships between the factors identified at a finer level, as well as to eventually identify new factors and their mutual influences. This in particular concerns the representational function and the need for its more detailed consideration within the explanatory theory, which is discussed in the following.

8.1.4 External Validity

External validity refers to the boundaries of *generalisability* of the research findings beyond the local context of the empirical observations. In the context of our research, we discuss the external validity of both our theoretical contributions and the explanatory theory.

Fundamental view on modelling and conceptual modelling languages. Given the underlying theories and the research method used, we believe that a fundamental view on modelling (Chapter 4) is general in nature, and thus applicable outside the immediate context of our explanatory theory. This view on modelling, grounded in semiotics and cognitive science, synthesises

the existing theoretical work (Section 4.2), while adding slight conceptual and terminological refinements (Section 4.3).

The proposition of a fundamental view on the role of conceptual modelling language is, in our view, applicable to conceptual and enterprise modelling, with the limitation that the representational function is not covered in equal detail and depth as the linguistic function. This choice has been taken consciously, and with the objective to first develop a better understanding of the understudied linguistic function. Then only can we discuss the challenges and solutions related of adequately accommodating both functions in the context of language engineering.

Explanatory theory. When it comes to the explanatory theory, we have decided to restrict its application scope to enterprise modelling. While we argued that the linguistic function of the conceptual modelling language is in general not sufficiently theoretically understood, we acknowledge that it has a specific importance in enterprise modelling context.

In the explanatory theory development, we were at the same time not concerned with *statistical generalisation*. At this stage, we develop, use and evaluate the explanatory theory as a “sensitizing device” [Klein and Myers, 1999]. According to Klein and Myers [1999], we thus are concerned with *analytic generalisation*: the basis for generalisation is built on the plausibility of logical reasoning used in the study and in drawing conclusions from it (principle of abstraction and generalisation [Klein and Myers, 1999]).

This focus is also due to the level of theoretical maturation of the explanatory theory. Namely, we are primarily concerned with a deeper understanding of the linguistic function of the conceptual modelling language, and its contribution in explaining phenomena occurring in the use of enterprise modelling languages. The focus of interpretive field study, at this stage of theory development, was to primarily evaluate the proposed theoretical elements intended for the linguistic function analysis (Sections 6.5.1, 6.5.4, and 7.4) and their adequacy as a “sensitizing device”.

The field study realised is chosen so that the linguistic function can be properly studied: in the field study realised, the linguistic function was clearly in focus, as opposed to the representation function. Therefore, the conducted field study certainly cannot be taken as a representative of cases where the representational function would be more in focus. Consequently, we have no empirical insight into how these two functions interplay, and how eventual tension between two functions would affect the use of a given modelling language in a more complex/challenging modelling setting. Consequently, although affirmative, current empirical evidence does not support generalisation in the statistical sense outside of the immediate field study context. In that sense, our current empirical evaluation should be considered as a preliminary evaluation of the explanatory theory.

Nevertheless, with the obtained empirical insight, we are confident about the feasibility of engaging into further theoretical refinements and additional empirical studies. In light of strengthening the external validity of our theory, a possible sampling strategy for further field studies may focus on more variety

in modelling configurations observed, in order to ‘test’ the capacity of our theory to explain a range of variation in modelling language use and adaptation strategies. For instance, future field studies could be oriented towards including a less ideal case than the one we had in the HEEL field study. It is also possible to envision that including a wider range of variation in modelling configurations, especially dis-confirmatory(negative) cases, could contribute to further investigate the boundaries of the explanatory theory. Finally, one can also imagine that, with sufficient empirical evaluation, the predictive capacity of the current theory could start to be assessed. This at least can concern the prediction of possible ‘accidents’ with regards to linguistic function, and based on e.g. the analysis of conceptual foundation of the modelling language in terms of dimensions proposed in Section 6.5.1. Ultimately, based on realised ‘accidents’, best practices and/or anti-patterns of effective language design can also surface. This remains a task for the further research.

8.2 Implications

Unlike the normative (Section 6.3.1) and communication (Section 6.3.2) perspectives on modelling language, which focus on structure in studying modelling language, the perspective taken in our research underlines the importance of understanding linguistic structure as closely interrelated with its content, i.e. conceptual knowledge. Adopting this baseline orientation from the cognitive-linguistics (Chapter 5), in our study of conceptual/enterprise modelling languages and their use in conceptualisation, we give primacy to concepts and semantics as primary linguistic phenomena.

While enterprise modelling languages often aim to enhance and potentially even change perspectives adopted in studying certain parts of the enterprise, their introduction is, however, not likely to modify the principles according to which human beings structure and use conceptual knowledge. In our view, language engineering efforts should rather rely on this understanding, instead of neglecting it, in order to effectively support knowledge creation and exchange. Given that many problems with the use of modelling languages are reported to occur already in conceptualisation stream, studying the linguistic function on cognitive-linguistic grounds offers an interesting set of insights towards language evaluation, engineering and learning.

8.2.1 Modelling Language as a Conceptual System: Underlying Pragmatics

Traditionally, pragmatics has been looked at as the source of problems, and ambiguities, and has been discarded in the analysis of language. The research in this thesis shows a different perspective that can be taken on this subject matter, and offers framework which involves pragmatics as integral dimension of modelling language studies. This in particular concerns the necessity to drop semantic-pragmatic dichotomy in the study of conceptual knowledge, as

suggested in Section 3.2.2.

Pragmatic coherence and use of modelling languages. Our research suggests that *pragmatic coherence of a conceptual structure* underlying modelling language may be one of the crucial qualities in the effective adoption and use of conceptual modelling languages. Not only does the understanding of any conceptual system rest on this inherent rationale, but each individual concept is understood in relation to the coherent whole of a the belonging conceptual systems. Our empirical insight shows that when such pragmatic coherence of a conceptual structure is lacking or is hindered, a greater effort is needed in understanding and using the language constructs. In addition, it may also require some kind of method-like guidance to facilitate the use of the modelling language. Additionally, the unclear pragmatic coherence in an engineered language may also be a factor leading to the selection of an inappropriate language in the first place, and consequently to various compensatory strategies in language use. Therefore, more attention should be paid to this dimension in modelling language studies.

Language evaluation. Towards language evaluation, our research also suggests that a more encompassing framework of analysis and evaluation may be necessary. Relating the value of language primarily to its use, we suggest that syntactic-semantic structures have to be evaluated in relation to patterns of knowledge in intended domains of interest that modelling languages target. To this end, we introduced a preliminary framework for the analysis of pragmatic rationale underlying modelling language and its organisation, which can be used to understand the patterns of use of language, as well as to guide the reflection on the language design. While this framework still has to mature, it indicates one of the ways in which pragmatics can be approached to complement the traditional syntax-semantics lens on modelling languages.

8.2.2 Language Engineering

These insights, in turn, suggest a more careful consideration of pragmatics in language design.

Co-constructive and evolutionary language engineering. The developed perspective on modelling languages appreciates a co-constructive [Lyytinen, 2006] relationship between language and reality. With regards to language engineering, our research implies that the (patterns of) use of modelling languages can be very informative with regards to the ‘goodness’ of language design, acting somewhat like a feedback loop system. This evolutionary philosophy of language engineering, illustrated in Figure 8.1, is in our view, a promising direction for the future of modelling language research. It may offer the platform of reconciling the ambition of language/knowledge reuse, without totally sacrificing the primary language functionality.

This philosophy requires also the lens through which the language use

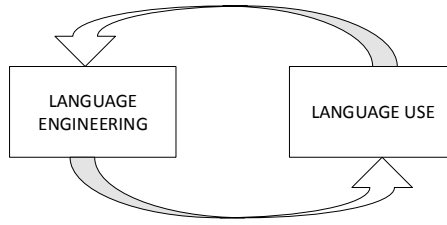


Figure 8.1: Co-construction of language and reality

patterns can be interpreted. We believe that our theoretical framework offers some guidance towards characterisation of linguistic structure, and the analysis of language use patterns, based on integral consideration of syntax, semantic and its underlying pragmatics.

Reference language and modular organisation. The core of such a philosophy of language engineering lies in the appreciation that the pragmatic richness needed by the modelling language cannot be fully predetermined, as well as that potential technological and designers’ biases are nearly impossible to avoid. In addition, the adaptive and evolving nature of conceptual knowledge calls for taking a more humble perspective as to what language engineering and standardisation can or cannot achieve in conceptual and enterprise modelling. In our view, this requires to relax the conception of normative language standard language [Bjeković et al., 2014b], more closer to the conception of reference language [Frank, 2014d]. In our view, the best an engineering modelling language can do is to provide an idealised, i.e. reference language, about some domain of interest, exactly at the level conceptual systems in natural language capitalise on human knowledge.

In addition, our research suggests two levels of organisation within a reference language: 1) the level which groups stable core of concepts which characterises a general perspective on the domain of interest (e.g. core concepts of process modelling), and 2) pragmatically-scoped chunks/modules which extend the conceptual core, depending on the classes of purposes intended to be covered (e.g. different chunks for organisational redesign, process documentation, as well as e.g. process simulation). The *right* language for a modelling situation at hand could then be woven out of the different chunks, based on the pragmatic needs of the given modelling effort. This also suggests that the pragmatic rationale of these ‘chunks’ should be made explicit and reflected in coherent conceptual structure. We believe this is one of the promising directions to explore in the future research.

This orientation opens interesting challenges for the development of mechanisms that support intelligent modelling language refinement, adaptation, combination, etc. [Zivkovic and Karagiannis, 2015], as well as the development of modelling infrastructures that accommodate the required flexibility, e.g. [Kimelman and Hirschman, 2011, Zarwin et al., 2014].

8.2.3 Learning Conceptual Modelling

The insights into the use of conceptual systems in conceptualisation offer some implications towards language learning and its application in conceptualisation, as well as scoping and organising language trainings.

Perspectivisation and language training. Fundamentally, in the context of conceptualisation, the ‘game of language’ actually consists in the game of shifting perspectives on the domain of interest, and adopting the most useful one in the given modelling context. The insights into cognitive linguistics shows that a human being is rather capable of adopting many different perspectives on different domains of interest: that capacity lies at the very core of human capacity of conceptualisation. Consequently, the main issue in learning a conceptual modelling language boils down to getting to understand its underlying perspective on the particular domain of interest, its pragmatic scope and core of its structuring.

Towards learning a modelling language and facilitating its understanding and adoption, this suggests that the primary focus of language training should be on identifying, communicating and exploring the *conceptual perspective* embodied in a modelling language, as means to frame particular domain of experience. To understand this perspective, we suggested in Section 6.5.1, that its background assumptions, focus, and core concepts are key elements to be identified, and their underlying pragmatic rationale clearly identified. This core of a ‘way of thinking’ is what the rest of *conceptual organisation* emerges from, and is made sense of. Additionally, in language processing, clear pragmatic rationale behind the proposed conceptual organisation is crucial: the overall structure rather than individual elements seem to have primacy. For language training programs, this insight suggest that the pragmatics underlying a particular conceptual structure should be elaborated on and clarified, next to the individual construct definitions, and syntactic-semantic considerations. This, in turn, also implies that a modelling language should first be defined with such a pragmatic coherence in mind (as discussed already in Section 8.2.2).

Two-steps conceptualisation. Our research suggest that a potential strategy to accommodate novice modeller/typical stakeholder may consist in more distinct separation between two levels of reflection involved in conceptualisation. First, novice modellers usually struggle to effectively manage cognitive load involved in conceptualisation. In addition, these participants are likely to struggle with an unknown/not functionally embodied ways of thinking present in a modelling language (especially in the case of a complex/comprehensive standards). This implies that, in these situations (e.g. specifically a collaborative modelling one), within the modelling process, conceptualisation stream may be ‘implemented’ in terms of two differentiated steps, i.e. focussed on domain conceptualisation in relation to purpose, and the second step focussing on ‘translating’ such conceptualisation into a target conceptual/enterprise modelling language. Besides intending to manage cognitive load of modelling tasks, this strategy may also bring essential questions of modelling to the fore, and allow for their focussed discussion. To further support such an organisation

of modelling process, this potentially also requires a reflection on the roles and competencies of people involved in the modelling process [Frederiks and van der Weide, 2006]. These considerations call for synthesis with the existing research in other close fields, such as collaborative modelling.

Part IV

Closing

CHAPTER 9

Conclusion

In this chapter, we summarise the contributions of our research, and discuss the future research directions. We start by summarising the thesis contributions (Section 9.1) and their answering of stated research questions (Section 9.2). Thereafter, we critically reflect on the research approach used (Section 9.3), and finally, suggest a possible future research agenda (Section 9.4).

9.1 Overview of Thesis Contributions

The thesis develops a theoretical framework for understanding and explaining the use of enterprise modelling languages. Approaching this topic from a socio-pragmatic constructivist stance, the developed theoretical framework looks at the modelling language in relation to the socio-pragmatic context of modelling, not only in relation to the challenges of mechanical manipulation of models.

Besides just allowing mechanical manipulations of representations, conceptual modelling languages are designed with the ambition to capitalise upon and reuse conceptual knowledge within some domains of experience. Our research emphasises the conceptual knowledge dimension as a crucial one for a better theoretical understanding of linguistic and representation functions of conceptual modelling languages (Sections 6.4–6.6). To this end, we draw on cognitive-linguistic understanding of the nature of conceptual knowledge and its functioning in human languages both for the purposes of conceptualisation and communication.

Our theoretical and empirical insight allows a different interpretation of phenomena occurring in language use, demonstrating that many challenges in use may stem primarily from the lack of clear pragmatic coherence in a linguistic structure of a modelling language.

We believe that our findings reveal the relevance of more closely studying the pragmatic dimension of conceptual and enterprise modelling languages for language engineering, which is still a marginalised research topic.

9.2 Answering the Individual Research Questions

The overarching research question of the thesis is formulated as follows:

What are the factors that affect the use of enterprise modelling languages?

The question is answered through the following questions:

RQ 1. *What is the role of purpose in modelling, and specifically, how does it affect the process of model creation?*

Based on a constructivist stance, and grounding in semiotics and cognitive sciences, we formulated the fundamental view on models and modelling which explicitly considers the role of purpose and its influence throughout the modelling process (Chapter 4). This contribution resulted from a critical synthesis of the existing theories, whereby we clarified the notions of domain and purpose and integrated our refinements in a coherent terminological and conceptual foundation. While refinements of this theoretical contribution is certainly possible, the depth of our development in the context of the thesis was decided based on the needs for the explanatory theory development. The developed view on modelling prepared the conceptual ground for answering **RQ 2**.

RQ 2. *What is the role of a modelling language in conceptual and enterprise modelling?*

This question is answered by developing a proposition of a twofold function of a conceptual modelling language, i.e. linguistic and representational function. We focus on providing a better theoretical understanding of the linguistic function. In doing so, we share the view of [Falkenberg et al., 1998, Frank, 2011a] that conceptual foundation of a modelling language is its crucial element, and that all other elements depend on it. We claim that a better understanding of how concepts function in relation to conceptualisation, and how humans acquire and organise conceptual knowledge, will allow us to understand linguistic function. Therefore, we ground the understanding of linguistic function in the advances of functional linguistics [Clark, 1993, Cruse, 2011], cognitive linguistics [Geeraerts, 2010], and cognitive science [Baddely, 2012, Lakoff, 1987]. Based on this insight, we propose to approach a linguistic structure of conceptual modelling language as any conceptual system, and

derive that modelling language use in conceptualisation is affected by its *embodiment* and *utility* of its linguistic structure. In addition, we also identify that the lack/existence of clear pragmatic rationale and conceptual coherence of the modelling language impacts its understanding, and effective use as a mediator of conceptualisation processes. To this end, we suggest a preliminary analytic framework that analysis of pragmatic rationale in a modelling language.

RQ 3. *What are the factors that shape the use of enterprise modelling languages?*

The conceptual framework developed in answering research questions **RQ 1** and **RQ 2** is used as a basis for explanatory theory development. Based on theoretical and empirical input, the formulated explanatory theory (Section 7.3–7.4) proposes that the cost-effective linguistic (and representational) function are the primary drivers of modelling language use, while factors such as e.g. resource availability, political factor, knowledge capitalisation and the characteristics of corresponding modelling infrastructure may attenuate the primary factors. Furthermore, the insights from the field study suggest that a clear pragmatic rationale of the linguistic structure of modelling language has a major impact on selecting, understanding and using the modelling language. These findings, however, require more research to clarify the implications on language engineering and language learning, for instance. Although implications have been already discussed in Section 8.2, more research is required to be conclusive. Finally, our empirical insight suggests that the presence of method-like guidance that accompanies the use of modelling language can to some extent attenuate the problems when its pragmatic coherence is hindered, and not clear.

RQ 4. *How can these factors contribute to the explanation of emergence of dialect-like variants of enterprise modelling languages in the actual contexts of their use?*

Based on the answers to **RQ 3**, and the primary and mediating factors identified, we considered the specific case of language adaptation emerging within the concrete modelling effort in the HEEL field study. Our analysis suggests that the adaptation of modelling language in the concrete modelling effort is rooted in its negative cost-effectiveness ratio, i.e. in its damaged functionality. However, depending on the other constraints (e.g. available resources and modelling infrastructure, as well as political constraints), the modelling language variant may take implicit or explicit form. While the modelling language is typically selected to capitalise on the existing ‘best practice’ or ‘knowledge’ embedded in that language, its application in the concrete context may ask for the adaptations, which may not be supported by the classical model editor/modelling infrastructure

associated with modelling languages. Consequently, implicit rather than explicitly defined language adaptation may be resulting from the lack of technological support for language refinement, combination etc. As an attempt to characterise different forms and extents of (originally selected) modelling language adaptations, and feed future reflections regarding language engineering, we suggest that the adopted conceptual perspective of a modelling language acts as the main denominators of the ‘way of thinking’ i.e. of delimiting a certain domain of interest, covered by the modelling language. In the selection of modelling language, not only the adequacy of individual concepts, or a set of concepts needs to be evaluated, but as well the entire conceptual perspective imposed on the domain of interest, therefore also the focus implied by the conceptual framing, as well as its pragmatic rationale.

When it comes to the adaptations emerging in the use of a modelling language, we suggested to broadly differentiate two levels of adaptation. When the modelling language used is slightly adapted in terms of detailed conceptual organisation, syntactic-semantic constraints, or notational variants, these variations can be considered as dialect-like variants of the original language motivated by the specificities of modelling context or model purpose. However, whenever the variations of selected modelling language entail a modification of the conceptual perspective of the modelling language, this automatically implies that a different way of thinking, i.e. different delimitation of domain is at stake. In other words, a different ‘language game’ is being created, i.e. a new modelling language. While the emergence of any class of modelling language variants are unavoidable, our results suggest that ensure a clear(er) pragmatic coherence of modelling language definition may contribute to its better understanding, but also to avoiding language use outside of designated application scope, thus avoiding unnecessary ‘accidents’.

9.3 Critical Reflection on the Research Approach

In this section, we discuss the challenges, advantages and limitations of the decisions taken in shaping our research approach.

9.3.1 Method Pluralism

In a multidisciplinary field like and IS and EM, combining the insights from multiple disciplines, but also combining multiple research methods can often be beneficial (if not necessary) for increasing the quality of research results. With this respect, the conceptual and methodological framework of *method pluralism* for IS, proposed by [Frank, 2006], has been of great support in structuring our research approach, in light of the topic of language use, which is obviously lying at the crossroads of many disciplines.

The method pluralism framework ‘embodies’ a high-level perspective on scientific research across the variety of research paradigms, approaches, and

concepts of scientific truth. As such, it allows for reflection on all tools of scientific research from a more neutral, and pragmatic point of view. In our view, this perspective is much needed in IS community, and is of particular value for young researchers, if only to be prompted of and eventually avoid the confinements of a dogmatic interpretations of science.

At the same time, we found that a clear simple and consistent terminological foundation of method pluralism framework offers an invaluable guide to structure, justify and communicate a multi-method research. Note that, also, when visualising the contributions of our research, we followed the meta-model proposed in [Frank, 2006], including its original colour-coding scheme.

9.3.2 Interpretive Approach

Ongoing modelling effort an in-depth understanding. The nature of our research subject is such that a close attendance to the processes going on within a modelling effort is advised. We estimated that relying on the *ex-post* data collected from the informants several months/years after the modelling exercises would not be adequate for our research objectives. In this context, the *ex-post* data runs the risk of being thin, context-stripped and unreliable, as informants may only selectively recall the events and decisions taken in a modelling effort. In contrast, the main value of interpretive approach (as well as the use of qualitative data) lies in the fact that it allows for gathering in-depth understanding of events and processes in relation to the their local context. This has the potential to reveal subtleties and complexities of the phenomena studied, which exactly was our priority. In shaping an interpretive field study of an in-depth character, we were aware of the risks that it may end up being a time-consuming endeavour. However, we saw no other possibility for getting deeper insights into our chosen research subject. In order to mitigate these risks and ensure positive outcome from the field study, we paid due attention to identifying boundaries of the observation (Section 7.2.3), and introduced several criteria pertaining to the selection of the field studies (Section 7.2).

Lack of control. When engaging in an observation of an *ongoing*, rather than a *past* modelling effort, the major risk involved is that the researcher cannot anticipate nor control for the eventual changes in the modelling configuration of the team, the objectives and the overall outcome of the modelling exercise. All these events may have a non-negligible impact on the field study relevance, or on the quality of collected data, and may often ask for re-assessing the planned data sources, and protocols of data collection. To this end, the researcher has to prepare back-up plans, and stay flexible about study design choices, regardless of how carefully these were reflected on *ax ante*. In the extreme case, it may even result in a need to leave the concrete study out of consideration and search for the new one. This, however, is a time and energy consuming job, but most of all requires a mind-set that accepts and can deal with a lack of total control. In our view, these challenges may be overwhelming for a younger researcher, unless properly supported by the larger research team, as advised by [Miles and Huberman, 1994]. Still, it demands a considerable effort and risk taking,

which is not necessarily promoted in the current academic culture [Frank, 2014a].

In our case, for instance, the collaborative modelling sessions were initially foreseen in the HEEL project, and we planned to record these sessions. During the course of the project, domain experts from the health sector did not really intervene in the modelling exercise itself, but had a more traditional role [Barjis, 2009] of providing insight from the domain, and to discuss and confirm on a rather general level (e.g. core activities, main processes etc.) the structuring of sectorial models per specific actor (e.g. laboratory). Internally to the RTO, the modelling team initially planned to have regular meetings and exchanges, and agreed to have these meetings recorded. However, due to resource constraints, and to some extent the culturally dominant way of working in the RTO, modellers ended up working individually on different model parts, and then synchronising their effort and reflections from time to time in a rather informal and unplanned meetings, or also through email conversations. Lastly, the team configuration reduced to one main modeller, with limited involvement of other team members. As the main informant was at the same time the most knowledgeable one, we decided not to discontinue the field study engagement. Having in mind the risks this choice induces with regards to the conclusion validity (as discussed in Section 8.1.2), instead of recordings of modelling sessions, we opted for interviews which serve as model walk-through sessions. In this context, we invited multiple informants, and informally discussed about choices taken in different model versions, in using the modelling language, and regarding any other relevant topic.

Next to that, the initially important participant of the modelling effort (which to some extent played the role of primary audience of the intended models) – the public agency – has informally but effectively withdrawn from the active participation mid-way through the HEEL project. According to the informal information obtained from various sources, the reason for this withdrawal seems to lie in political reasons of the technical officer in the public agency in charge of the existing tool, and this despite the fact that management of the public agency supported and approved the adopted modelling approach. Such a situation could not have been anticipated neither by the project team nor by the researcher, and in a slightly different setting, the project may have been suspended, which again would have required to discontinue the field study and search for a new one.

Data access. One could imagine that conceptual and enterprise modelling is widely performed, and that there should not be any major difficulty in identifying and obtaining ‘good’ field studies. Nonetheless, in two out of three potential partners, due to the intellectual property protection policies in their respective organisations, the sharing of model artefacts was not possible (In one organisation, there was the willingness to share the diagrams from which all the words and labels would be removed). The availability of model artefacts was, however, assessed as crucial for the quality of our analysis, and with regards to evaluating our theoretical propositions and assumptions. Whereas we could have been more relaxed with regards to the necessity to observe an ongoing

modelling effort (still acknowledging the risks of getting less ‘rich’ data), it was in our view critical not to rely solely on the interviews in data collection. Due to these challenges, and although we did not initially aim to only conduct one field study, we were forced to abandon other potential field study engagements. While arguably a single in-depth field study induces limitations with respect to the external validity of the research results (Section 8.1.4), this setting also allows to obtain very rich insights and strengthen the conclusion validity of our findings (Section 8.1.2). For the current state of theoretical development, the latter was considered more important than the external validity, as it allowed for the evaluation of developed theoretical constructs. Consequently, despite the involved challenges and risks, we are confident about the decisions taken in selecting and shaping the interpretive field study.

9.4 Proposals For Further Research

In the following, we identify and discuss possible directions in terms of which the current theory can be further developed, refined and evaluated.

9.4.1 Linguistic Function and Language Use

We believe that the understanding of linguistic function and its influence in language use can be further enhanced. In particular, this refers to the following topics.

Explanatory power of the theory. Based on our previous discussions (Section 8.1.4), one of the immediate directions towards maturing the explanatory theory could be to strengthen our conclusions through a more varied sample across future interpretive field studies. At the same time, this would allow us to strengthen the external validity of explanatory theory, and to start investigating the predictive capacity of the theory, as suggested in Section 8.1.4.

Novice modeller. Our proposition regarding linguistic function has been partially validated in the interpretive field study. As already mentioned, the fact that we had as our main informant the modeller with a long-term experience, and with the capacity to reflect, and openly share the reflection on the very use of language – in parallel with the modelling activities – was of great value for our observation and analysis. However, we have not been able to evaluate and analyse if the proposed dimensions of modelling language, and the proposed analysis of functioning would hold in the case of novice modellers, and/or whether additional elements would need to be included in our analytic framework to cater for this case. More specifically, in the case of novice modellers, the further research may seek to clarify the effect of e.g. overload of relationships within modelling language such as ArchiMate, or partial overlapping of constructs, ambiguous definition of concepts on the language use.

Influence of notation. Recently, the influence of visual notation design on cognitive processing of models and modelling languages [Moody, 2009] became

a subject of research interest. This research work is complementary to our focus in the theory development. While we did identify this dimension as relevant, we did not treat it in detail. We claimed that, by virtue of mirroring the linguistic structure of modelling language, visual notation may indeed impact its processing. However, our focus was at this point the conceptual dimension in modelling language use. Towards future theoretical development, the representation function, as well as, more specifically, the details of visual notation influence – both theoretically and empirically – should be included in the explanatory theory. Given that the above-mentioned work on visual notation finds its grounding in the similar body of knowledge, i.e. in the principles of cognitive functioning, the integration of the notation aspect can only be further enhanced.

Influence of method guidance to language use. While we discussed the method-like guidance as a factor that can help attenuate the effects of unclear pragmatic rationale of the modelling language, and as such have significant impact on modelling language functionality. However, we did not investigate more into the details the effective forms of guidance to language use both within and outside of the language specification. While this is also due to limited empirical evidence, we suggest this as a relevant future research topic.

9.4.2 Conceptual Modelling and Theories of Language Learning

Our current theoretical insight into nature of linguistic function and its influence in conceptualisation is based on the cognitive-linguistic explanation of conceptual knowledge structuring and use. This in turn offers interesting insights into learning of conceptual modelling (Section 8.2.3). Towards further theoretical improvement, we suggest that theories of learning can be used to explore some principles and recommendations with regards to how to best introduce and adopt new ways of thinking. These insights can be fruitful not only towards the organisation of training programs, but would also be transferable to situations requiring strong business stakeholder involvement in the process of modelling. While, in this context, we primarily focus on facilitating the linguistic function of conceptual/enterprise modelling language, it is obvious that theories of learning can be informative towards the design of the most appropriate/involving, and the least intrusive mode of interaction in the training program and/or modelling process [Zarwin et al., 2014], such as e.g. 3D physical space or objects, tangible interfaces etc. As such, it has the potential to impact and inform the design of representation system of the modelling language.

9.4.3 Language Use in Collaborative Modelling

It is widely known that the critical step in collaborative modelling represent the negotiation between different perspectives on domain to be addressed by the model, form that model should take, and purpose the model is to fulfil, and reaching the consensus on these issues. As part of the further research,

we deem important to investigate to which extent our fundamental view on the role of conceptual modelling language is valid, and what refinements are needed, in a collaborative modelling setting.

In collaborative modelling, a modelling language is often regarded as solution for a “common language” problem, claiming that it can act as a platform that bridges between different professional terminologies. However, we believe that this view is rather simplistic, and would expect that a common view on a modelling problem is constructed in line with the particular goals and within the context of a modelling effort. To this end, the modelling language, if used in a collaborative modelling effort, may or may not provide adequate support. More fundamentally, and due to the involved processes of group negotiation of a common view, it may be relevant to investigate levels of reflection present in conceptualisation of the domain, as well as at which point the modelling language functions come to the fore. For subsequent theoretical development in this regards, the study of collaborative modelling literature is required, but also the field studies in which the collaborative modelling efforts are studied. When it comes to the study of modelling language role in collaborative modelling, it is highly likely that the a joint consideration of communication-oriented (Section 6.3.2) and cognitive-linguistic-oriented perspectives may be fruitfully combined to reach better insights, also given their similarity and complementarity.

9.4.4 Model Monopoly as Factor of Modelling Language Selection and Use

In [Wyssusek, 2005], Wyssusek proposes to use the notion of *model power* or *model monopoly* introduced by [Braten, 1973] to analyse the influence that introduction of enterprise systems such as ERP packages has on shaping the organisational knowledge. This influence is conceptualised as the effect of introducing a new (linguistically engineered) discourse about organisation, i.e. that of ERP, to the existing discourse in organisation, whose meaning is rooted in a history of symbolic interaction. At the inter-discourse level, the ERP system already have “model power” or “model monopoly”, as by their design, they come with the claim to have more comprehensive knowledge about organisations, while also incorporating “best practices”. As a consequence, the old discourse is forced to accept the one with greater “model power”, as its challenging, questioning and altering is not possible.

It is possible to draw some parallels regarding the *political* and/or *normative* pressure towards selection of modelling language, that may stem from the fact that a certain language is standardised. Indeed, it can be observed in the modelling practice that standardised modelling language may be perceived as somehow more legitimate per se, and this regardless of the goals of modelling effort and nature of the task at hand. Additionally, the “model power” of a (standard) modelling language may be drawn from the well-known vendor lock-in situation, whereby the use in organisations model editor and/or model management environment (e.g. verification, model repository, code generation,

etc.) based on a modelling language. In this case, the use of these tools may be forced onto the projects within the organisation, at the expense of pragmatic requirements.

It is quite possible that in this situation, many accidents may happen, and it can be interesting to observe empirically and get more insights into it. From the more theoretical perspective, it will be interesting to conceptualise these classes of situations and include them into proposed analytic framework tackling modelling language use, assessing whether the existing categories are able to explain this kind of extreme situations. For instance, what will happen in this case with the linguistic function? What kinds of challenges may be observed, and can they be “captured” within the existing categories present in the cognitive-linguistic explanation of functioning of conceptual systems in conceptualisation? In the extreme cases of negative linguistic function cost-effectiveness, can we observe some kind of workarounds [Alter, 2014] being employed as a compensation, and along which elements of linguistic structure are they most likely to appear? This topic can also allow to increase the validity of the explanatory theory.

9.5 Closing Remarks

In this thesis, we have argued that the area of modelling pragmatics [Thalheim, 2012], and more specifically, the use of conceptual/enterprise modelling languages, requires more attention both in modelling language research and engineering.

The results of our thesis contribute to the existing body of knowledge at several levels. The developed theoretical contribution provides a basis for the study of conceptual and enterprise modelling languages, from a perspective which is alternative to, yet in a way complementary to, the ontological approach which dominates conceptual modelling research. While dominantly techno-centric orientation to modelling and modelling languages can be understood from the historical perspective, it is not sufficient for understanding and addressing the challenges of modern day enterprise modelling [Frank, 2014b]. The theoretical reflection in this thesis offers a broader consideration of modelling languages, going beyond just the isolated study of syntactic-semantic code, and drawing on insights into context- and intention-dependency, as well as evolving nature of both conceptual knowledge and language. This theoretical lens has been used in the development of explanatory theory to obtain an understanding of the language, specifically regarding linguistic function. The empirical evidence supports the importance of clear pragmatics behind the linguistic structure, both in its learning and use.

We hope that our research results can be taken in synergy with research works tackling pragmatic dimension in studies of modelling process and modelling language selection, and be further refined to set the basis for modelling languages and modelling infrastructures that cater for modelling pragmatics.

Bibliography

- P.J. Agerfalk and O. Eriksson. Pragmatization of conceptual modelling. In Stanislaw Wrycza, editor, *ECIS*, pages 416–428, 2002.
- Jens Allwood. On the Distinctions between Semantics and Pragmatics. In W. Klein and W.Levelt, editors, *Crossing the Boundaries in Linguistics*, pages 177–189. D.Reidel Publishing Company, 1981.
- Steven Alter. Theory of Workrounds. *Communications of the Association for Information Systems*, 34, Article 55., 2014.
- Ateret Anaby-Tavor, David Amid, Amit Fisher, Avivit Bercovici, Harold Ossher, Matthew Callery, Michael Desmond, Sophia Krasikov, and Ian Simmonds. Insights into enterprise conceptual modeling. *Data Knowl. Eng.*, 69(12): 1302–1318, 2010.
- Claudia P. Ayala, Carlos Cares, Juan Pablo Carvallo, Gemma Grau, Mariela Haya, Guadalupe Salazar, Xavier Franch, Enric Mayol, and Carme Quer. A Comparative Analysis of i*-Based Agent-Oriented Modeling Languages. In *Proceedings of the 17th International Conference on Software Engineering and Knowledge Engineering (SEKE'2005)*, pages 43–50, 2005.
- Alan Baddely. Working memory: Theories, models and controversies. *Annual Review of Psychology*, 63:1–29, 2012.
- J. Barjis. Collaborative, Participative and Interactive Enterprise Modeling. In *ICEIS*, pages 651–662, 2009.
- P. Bernus and L. Nemes. A framework to define a generic enterprise reference architecture and methodology. *Computer Integrated Manufacturing Systems*, 9(3):179–191, 1996.
- Jean Bézivin. On the unification power of models. *SoSym*, 4(2):171–188, 2005.

- Martin Bichler, Ulrich Frank, David E. Avison, Julien Malaurent, Peter Fettke, Dirk Hovorka, Jan Krämer, Daniel Schnurr, Benjamin Müller, Leena Suhl, and Bernhard Thalheim. Theories in business and information systems engineering. *Business & Information Systems Engineering*, 58(4):291–319, 2016. doi: 10.1007/s12599-016-0439-z. URL <https://doi.org/10.1007/s12599-016-0439-z>.
- M. Bjeković, H. A. Proper, and J-S. Sottet. Towards a coherent enterprise modelling landscape. In *PoEM (Short Papers)*. CEUR-WS.org, 2012.
- M. Bjeković, Jean-Sebastien Sottet, Jean-Marie Favre, and Henderik Alex Proper. A Framework for Natural Enterprise Modelling. In *IEEE 15th Conference on Business Informatics, CBI 2013*, pages 79–84, 2013. doi: 10.1109/CBI.2013.20. URL <http://dx.doi.org/10.1109/CBI.2013.20>.
- M. Bjeković, H.A. Proper, and Jean-Sébastien Sottet. Embracing Pragmatics. In *ER 2014*, pages 431–444, 2014a. doi: 10.1007/978-3-319-12206-9_37. URL http://dx.doi.org/10.1007/978-3-319-12206-9_37.
- Marija Bjeković and Henderik Alex Proper. Challenges of modelling landscapes: Pragmatics swept under the carpet? In *Third International Symposium, BMSD*, pages 11–22, 2013. URL <http://www.is-bmsd.org/Documents/ProceedingsOfThirdBMSD.pdf>.
- Marija Bjeković, Henderik A. Proper, and Jean-Sébastien Sottet. Enterprise Modelling Languages - Just Enough Standardisation? In *BMSD, Revised Selected Papers*. Springer, 2014b. To Appear.
- P. van Bommel, S.J.B.A. Hoppenbrouwers, H.A. Proper, and J. Roelofs. Concepts and Strategies for Quality of Modeling. In *Innovations in Inf. Syst. Modeling*, chapter 9. IGI Publishing, 2008.
- Stein Braten. Model monopoly and communication: system theoretical notes on democratization. *Acta Sociologica*, 16(2):98–107, 1973.
- Richard Braun and Werner Esswein. Classification of Domain-Specific BPMN Extensions. In *PoEM*, pages 42–57, 2014.
- Sjaak Brinkkemper, Motoshi Saeki, and Frank Harmsen. Meta-modelling based assembly techniques for situational method engineering. *Inf. Syst.*, 24(3):209–228, 1999. doi: 10.1016/S0306-4379(99)00016-2. URL [http://dx.doi.org/10.1016/S0306-4379\(99\)00016-2](http://dx.doi.org/10.1016/S0306-4379(99)00016-2).
- Jr. J. A. Bubenko, A. Persson, and J. Stirna. An Intentional Perspective on Enterprise Modeling. In *Intentional Perspectives on Information Systems Engineering*, pages 215–237. Springer, 2010.
- David Chen, Guy Doumeingts, and François Vernadat. Architectures for enterprise integration and interoperability: Past, present and future. *Computers in Industry*, 59(7):647 – 659, 2008. ISSN 0166-3615. doi: 10.1016/j.compind.2007.12.016. URL <http://www.sciencedirect.com/>
-

- science/article/pii/S0166361508000365. *Enterprise Integration and Interoperability in Manufacturing Systems*.
- Peter P. Chen. A preliminary framework for entity-relationship models. In *ER'81*, pages 19–28, 1981.
- Peter Pin-Shan Chen. The entity-relationship model—toward a unified view of data. *ACM Trans. Database Syst.*, 1(1):9–36, March 1976. ISSN 0362-5915. doi: 10.1145/320434.320440. URL <http://doi.acm.org/10.1145/320434.320440>.
- Alan Cienki. Frames, Idealized Cognitive Models, and Domains. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 170–187. Oxford University Press, 2010.
- H.H. Clark. *Arenas of Language Use*. University of Chicago Press, 1993.
- Harris M. Cooper. Organizing knowledge syntheses: A taxonomy of literature reviews. *Knowledge in Society*, 1:1:104–126, March 1988.
- A. Cruse. *Meaning in Language: An Introduction to Semantics and Pragmatics*. Oxford Textbooks in Linguistics. Oxford University Press, 2011. ISBN 9780199559466.
- Islay Davies, Peter F. Green, Michael Rosemann, Marta Indulska, and Stan Gallo. How do practitioners use conceptual modeling in practice? *Data Knowl. Eng.*, 58(3):358–380, 2006.
- Tineke M. Egyedi. Standard-compliant, but incompatible?! *Computer Standards & Interfaces*, 29(6):605–613, 2007.
- Owen Eriksson, Brian Henderson-Sellers, and P.J. Agerfalk. Ontological and linguistic metamodelling revisited: A language use approach. *Information and Software Technology*, (0):–, 2013. ISSN 0950-5849. doi: <http://dx.doi.org/10.1016/j.infsof.2013.07.008>. URL <http://www.sciencedirect.com/science/article/pii/S0950584913001547>.
- E. D. Falkenberg, W. Hesse, P. Lindgreen, B. E. Nilsson, J.L.H. Oei, C. Rolland, R.K. Stamper, F.J.M. Van Assche, A.A. Verrijn-Stuart, and K. Voss. FRISCO - A Framework of Information System Concepts. Technical report, IFIP WG 8.1, 1998.
- Gilles Fauconnier. Mental Spaces. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 351–376. Oxford University Press, 2010.
- J.M. Favre. Megamodeling and Etymology – A Story of Words: From MED to MDE via MODEL in five milleniums. In *Transformation Techniques in Software Engineering*. Schloss Dagstuhl, Germany, 2006.
-

- H Fernández Fernández, Elías Palacios-González, Vicente García-Díaz, G Pelayo, B Cristina Bustelo, Oscar Sanjuán Martínez, and Juan Manuel Cueva Lovelle. SBPMN – An Easier Business Process Modeling Notation for Business Users. *Computer Standards & Interfaces*, 32(1):18–28, 2010.
- Anthony Finkelstein, Jeff Kramer, Bashar Nuseibeh, L. Finkelstein, and Michael Goedicke. Viewpoints: A framework for integrating multiple perspectives in system development. *International Journal of Software Engineering and Knowledge Engineering*, 2(1):31–57, 1992.
- U. Frank. Multi-perspective Enterprise Modeling (MEMO) - Conceptual Framework and Modeling Languages. In *HICSS'02*, volume 3, page 72, 2002.
- U. Frank. Some Guidelines for the Conception of Domain-Specific Modelling Languages. In *EMISA*, pages 93–106, 2011a. ISBN 978-3-88579-284-0.
- Ulrich Frank. Evaluating Modelling Languages: Relevant Issues, Epistemological Challenges and a Preliminary Research Framework. Technical Report 15, University Koblenz-Landau, Germany, 1998.
- Ulrich Frank. Towards a Pluralistic Conception of Research Methods in Information Systems Research. Technical Report ICB-Research Report No.7, University Duisburg-Essen, 2006. revised version.
- Ulrich Frank. Multi-perspective enterprise modelling: Background and terminological foundation. Technical Report ICB-Research Report No. 46, University of Duisburg,Essen, 2011b.
- Ulrich Frank. Domain-specific modeling languages: Requirements analysis and design guidelines. In *Domain Engineering, Product Lines, Languages, and Conceptual Models*, pages 133–157. 2013. doi: 10.1007/978-3-642-36654-3_6. URL http://dx.doi.org/10.1007/978-3-642-36654-3_6.
- Ulrich Frank. Higher Value of Research by Promoting Value for Researchers. *Communications of the Association for Information Systems*, 34, 2014a. URL <http://aisel.aisnet.org/cais/vol134/iss1/43>. Article 43.
- Ulrich Frank. Multi-perspective enterprise modeling: foundational concepts, prospects and future research challenges. *Software and System Modeling*, 13(3):941–962, 2014b. doi: 10.1007/s10270-012-0273-9. URL <http://dx.doi.org/10.1007/s10270-012-0273-9>.
- Ulrich Frank. Multilevel modeling - toward a new paradigm of conceptual modeling and information systems design. *Business & Information Systems Engineering*, 6(6):319–337, 2014c. doi: 10.1007/s12599-014-0350-4. URL <https://doi.org/10.1007/s12599-014-0350-4>.
- Ulrich Frank. Enterprise modelling: The next steps. *Enterprise Modelling and Information Systems Architectures*, 9(1):22–37, 2014d. URL <http://www.springerprofessional.de/5512082.html>.
-

- Ulrich Frank. Theories in light of contingency and change: Possible future world and well-grounded hope as a supplement to truth. In *Proceedings of HICSS 2017*, pages 5727–5736. 2017.
- Paul J. M. Frederiks and Theo P. van der Weide. Information modeling: The process and the required competencies of its participants. *Data Knowl. Eng.*, 58(1):4–20, 2006. doi: 10.1016/j.datak.2005.05.007. URL <http://dx.doi.org/10.1016/j.datak.2005.05.007>.
- Herbert Geeraerts, Dirk andÂ Cuyckens, editor. *The Oxford Handbook of Cognitive Linguistics*. Oxford University Press, 2010.
- Varun Grover, Kalle Lyytinen, Ananth Srinivasan, and Bernard CY Tan. Contributing to rigorous and forward thinking explanatory theory. *Journal of the Association for Information Systems*, 9(2):40–47, February 2008.
- David Harel and Bernhard Rumpe. Meaningful Modeling: What’s the Semantics of ”Semantics”? *IEEE Computer*, 37(10):64–72, 2004.
- Mounira Harzallah, Giuseppe Berio, and Andreas L. Opdahl. New perspectives in ontological analysis: Guidelines and rules for incorporating modelling languages into ueml. *Inf. Syst.*, 37(5):484–507, 2012.
- O. Henfridsson, K. Kautz, Bjørn Erik Munkvold, and Rossi M., editors. *Scandinavian Journal of Information Systems*, volume 18, 2006.
- S. Hoppenbrouwers and I. Wilmont. Focused Conceptualisation: Framing Questioning and Answering in Model-Oriented Dialogue Games. In *PoEM*, pages 190–204, 2010.
- S.J.B.A. Hoppenbrouwers. *Freezing Language; Conceptualisation processes in ICT supported organisations*. PhD thesis, University of Nijmegen, The Netherlands, 2003.
- S.J.B.A. Hoppenbrouwers, H.A. Proper, and V.E. van Reijswoud. Navigating the Methodology Jungle – The communicative role of modelling techniques in information system development. *Computing Letters*, 1(3), 2005a.
- S.J.B.A. Hoppenbrouwers, H.A. Proper, and T.P. van der Weide. A Fundamental View on the Process of Conceptual Modeling. In *ER*, pages 128–143, 2005b.
- S.J.B.A. Hoppenbrouwers, H.A. Proper, and Th.P. van der Weide. Understanding the Requirements on Modelling Techniques. In *CAiSE*, pages 262–276, 2005c. ISBN ISBN-10: 3540260951.
- M.-E. Iacob, H. Jonkers, M.M. Lankhorst, H.A. Proper, and D.A.C. Quartel. *ArchiMate 2.0 Specification*. The Open Group, 2012. ISBN ISBN-10: 1937218003.
- Mark Johnson. *The body in the mind: The bodily basis of meaning, imagination, and reason*. The University of Chicago Press, 1987.
-

- Julia Kaidalova, Ulf Seigerroth, Tomasz Kaczmarek, and Nikolay Shilov. Practical Challenges of Enterprise Modeling in the Light of Business and IT Alignment. In *PoEM 2012*, pages 31–45, 2012.
- D. Karagiannis and P. Höfferer. Metamodels in Action: An overview. In *ICSOFT (1)*, 2006.
- Thomas Karbe. Conceptions and context as a fundament for the representation of knowledge artifacts. *Journal of Systemics, Cybernetics, and Informatics*, Vol. 5, special issue: Collaborative Enterprises:98–103, 2011.
- Roland Kaschek. A Semantic Analysis of Shared References. In *ER*, pages 88–95, 2013.
- D. Kimelman and K. Hirschman. A Spectrum of Flexibility-Lowering Barriers to Modeling Tool Adoption. In *ICSE FlexiTools Workshop*, 2011.
- Heinz K. Klein and Michael D. Myers. A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, 23(1):67–93, March 1999 1999. URL <http://www.jstor.org/stable/249410>.
- Carol Kort and Jaap Gordjin. Modeling Strategic Partnerships Using the e3value Ontology: A Field Study in the Banking Industry. In *Handbook of Ontologies for Business Interaction*, pages 310–325. IGI Global, 2008.
- Kurt Kossanke and François B. Vernadat. CIM-OSA: A reference architecture for CIM. In *Human Aspects in Computer Integrated Manufacturing, Proceedings of the IFIP TC5 / WG5.3 Eight International PROLAMAT Conference, Man in CIM. Tokyo, Japan, 24-26 June 1992*, pages 41–48, 1992.
- J. Krogstie, G. Sindre, and H. D. Jørgensen. Process models representing knowledge for action: a revised quality framework. *EJIS*, 15(1):91–102, 2006.
- John Krogstie. Discussion on the article ”on ontological foundations of conceptual modelling”. *Scandinavian J. Inf. Systems*, 18(1), 2006.
- John Krogstie. *Model-Based Development and Evolution of Information Systems - A Quality Approach*. Springer, 2012. ISBN 978-1-4471-2935-6.
- George Lakoff. *Women, Fire, and Dangerous Things, What Categories Reveal about the Mind*. The University of Chicago Press, 1987.
- George Lakoff and Mark Johnson. *Metaphors we live by*. The University of Chicago Press, 1980.
- George Lakoff and Mark Johnson. *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. Basic Books, New York, 1999.
- Roland W. Langacker. Cognitive Grammar. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 421–462. Oxford University Press, 2010.

- Ronald W. Langacker. *Foundations of cognitive grammar, Theoretical prerequisites*, volume Vol 1. Stanford University Press, 1987.
- Ronald W. Langacker. *Foundations of cognitive grammar, Descriptive application*, volume Vol. 2. Stanford University Press, 1991.
- M. M. Lankhorst, H. A. Proper, and H. Jonkers. The Anatomy of the ArchiMate Language. *IJISMD*, 1(1):1–32, 2010.
- Barbara Lewandowska-Tomaszczyk. Polysemy, Prototypes, and Radial Categories. In *The Oxford Handbook of Cognitive Linguistics*, pages 139–168. Oxford University Press, 2010.
- Kalle Lyytinen. Theories of language and information systems: An appraisal of alternative language views for information systems. In *Proceedings of the 5th International Conference on Information Systems, ICIS 1984, Tucson, Arizona, USA, 1984*, page 1, 1984. URL <http://aisel.aisnet.org/icis1984/1>.
- Kalle Lyytinen. ICIS paper: Implications of theories of language for information systems. *MIS Quarterly*, 9(1):61–74, 1985. URL <http://misq.org/implications-of-theories-of-language-for-information-systems.html>.
- Kalle Lyytinen. The struggle with the language in the it–why is lap not in the mainstream. In *International Working Conference on the Language-Action Perspective on Communication Modelling (LAP)*, New Brunswick, NJ, 2004.
- Kalle Lyytinen. "Ontological Foundations of Conceptual Modelling" by Boris Wyssusek – a Critical Response. *SJIS*, 18(1), 2006.
- Bernd Mahr. Information science and the logic of models. *Software and System Modeling*, pages 365–383, 2009.
- Bernd Mahr. On judgements and propositions. *ECEASST*, 26, 2010a.
- Bernd Mahr. Position statement: Models in software and systems development. *ECEASST*, 30, 2010b.
- Bernd Mahr. On the epistemology of models. In G. Abel and J. Conant, editors, *Rethinking Epistemology*, volume 1, pages 301–352. De Gruyter, 2011.
- Bernd Mahr. On the epistemology of models. In G. Abel and J. Conant, editors, *Rethinking Epistemology*, volume 1. De Gruyter, 2012.
- Ivano Malavolta, Patricia Lago, Henry Muccini, Patrizio Pelliccione, and Antony Tang. What Industry Needs from Architectural Languages: A Survey. *IEEE Trans. Soft. Eng.*, 39(6):869–891, 2013.
- Christina McAfee. The Lingusitic Relativity Theory and Benjamin Lee Whorf. *The McMaster Journal of Communication*, 1(1), 2004.
-

- Mathew B. Miles and A. Michael Huberman. *Qualitative Data Analysis: an expanded sourcebook*. SAGE Publications, second edition edition, 1994.
- D.L. Moody. The “Physics” of Notations: Toward a Scientific Basis for Constructing Visual Notations in Software Engineering. *IEEE Trans. Soft. Eng.*, 35(6):756–779, 2009. doi: 10.1109/TSE.2009.67.
- Charles W. Morris. *Signs, Language and Behaviour*. Prentice Hall, 1946.
- Jan Nuyts. Cognitive linguistics and functional linguistics. In H-Cuykens D. Geeraerts, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 543–565. Oxford University Press, 2010.
- Todd Oakley. Image schemas. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 214–235. Oxford University Press, 2010.
- J.L.A. Oei, L.J.G.T. van Hemmen, E.D. Falkenberg, and S. Brinkkemper. The Meta Model Hierarchy: A Framework for Information Systems Concepts and Techniques. Technical Report CSI-R9217, Radboud University Nijmegen, July 1992.
- J.L.H. Oei and E.D. Falkenberg. Harmonization of Information Systems Modelling and Specification Techniques. Technical Report 94-07, Technical University Twente, The Netherlands, 1994.
- OMG. UML 2.0 Superstructure Specification – Final Adopted Specification. Technical Report 03-08-02, The Object Management Group, August 2003.
- OMG. Unified Modeling Language Specification, Version 2.0, 2005. URL <http://www.omg.org/spec/UML/2.0/>.
- OMG. Business Process Model and Notation (BPMN), Version 2.0, January 2011. URL <http://www.omg.org/spec/BPMN/2.0>.
- A.L. Opdahl. Anatomy of the unified enterprise modelling ontology. *Enterprise Interoperability*, 76:163–176, 2011.
- Harold Ossher, Rachel K. E. Bellamy, David Amid, Ateret Anaby-Tavor, Matthew Callery, Michael Desmond, Jacqueline de Vries, Amit Fisher, Thomas Fraunhofer, Sophia Krasikov, Ian Simmonds, and Calvin Swart. Business insight toolkit: Flexible pre-requirements modeling. In *ICSE Companion*, pages 423–424. IEEE, 2009. ISBN 978-1-4244-3494-7.
- Erik Pederson. Cognitive Linguistics and Linguistic Relativity. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 1012–1044. Oxford University Press, 2010.
- Henderik Alex Proper, Alex A. Verrijn-Stuart, and Stijn Hoppenbrouwers. On Utility-based Selection of Architecture-Modelling Concepts. In *APCCM 2005*, pages 25–34, 2005.
-

- Jan Recker. Opportunities and constraints: the current struggle with BPMN. *Business Process Management Journal*, 16(1):181–201, 2010.
- Peter Rittgen. Negotiating Models. In *CAiSE*, pages 561–573, 2007.
- Tim Rohrer. Embodiment and Experientialism. In H. Geeraerts, D. and Å Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 25–47. Oxford University Press, 2010.
- J. Rothenberg. The Nature of Modeling. In *Artificial intelligence, simulation & modeling*, pages 75–92. John Wiley & Sons, Inc., USA, 1989. ISBN 0-471-60599-9. URL <http://dl.acm.org/citation.cfm?id=73119.73122>.
- Per Runeson and Martin Höst. Guidelines for conducting and reporting case study research in software engineering. *Empirical Software Engineering*, 14(2):131, 2008. ISSN 1573-7616. doi: 10.1007/s10664-008-9102-8. URL <http://dx.doi.org/10.1007/s10664-008-9102-8>.
- Kurt Sandkuhl and Frank Lillehagen. The Early Phases of Enterprise Knowledge Modelling: Practices and Experiences from Scaffolding and Scoping. In *PoEM*, pages 1–14. 2008. ISBN 978-3-540-89217-5. doi: 10.1007/978-3-540-89218-2_1. URL http://dx.doi.org/10.1007/978-3-540-89218-2_1.
- H-J. Schmid. Entrenchment, Salience, and Basic Levels. In H. Geeraerts, D. and Å Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 117–138. Oxford University Press, 2010.
- Thomas Lloyd Short. *Peirce’s Theory of Signs*. Cambridge University Press, 2007.
- Herbert Stachowiak. Models. In *Scientific Thought, some underlying concepts, methods and procedures*, chapter 8, pages 145–166. Mouton/UNESCO, Paris, 1972.
- Ronald Stamper, Kecheng Liu, Mark Hafkamp, and Yasser Ades. Understanding the roles of signs and norms in organizations - a semiotic approach to information systems design. *Behaviour & Information Technology*, 19(1):15–27, 2000. doi: 10.1080/014492900118768. URL <http://www.tandfonline.com/doi/abs/10.1080/014492900118768>.
- Janis Stirna and Anne Persson. Evolution of an Enterprise Modeling Method - Next Generation Improvements of EKD. In *PoEM 2012*, pages 1–15, 2012a.
- Janis Stirna and Anne Persson. Purpose driven competency planning for enterprise modeling projects. In *CAiSE*, pages 662–677. Springer, 2012b. ISBN 978-3-642-31094-2.
- John R. Taylor. Cognitive Linguistics and Autonomous Linguistics. In H. Geeraerts, D. and Å Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 566–588. Oxford University Press, 2010.
-

- B. Thalheim. The Theory of Conceptual Models, the Theory of Conceptual Modelling and Foundations of Conceptual Modelling. In *Handbook of Conceptual Modeling*, pages 543–577. Springer, 2011.
- Bernhard Thalheim. Syntax, Semantics and Pragmatics of Conceptual Modelling. In *NLDB*, pages 1–10, 2012.
- Bernhard Thalheim. The Conception of the Model. In *BIS*, pages 113–124, 2013.
- Iman Tohidian. Examining Linguistic Relativity Hypothesis as One of the Main Views on the Relationship Between Language and Thought. *Journal of Psycholinguistic Research*, 38(1):65–74, 2009.
- David Tuggy. Schematicity. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 82–116. Oxford University Press, 2010.
- Dirk van der Linden. *Personal Semantics of Meta-Concepts in Conceptual Modeling Languages*. PhD thesis, Radboud Universiteit Nijmegen, the Netherlands, 2015.
- Arie Verhagen. Construal and Perspectivization. In H. Geeraerts, D. and Cuyckens, editor, *The Oxford Handbook of Cognitive Linguistics*, pages 48–81. Oxford University Press, 2010.
- Francois Vernadat. UEMML: Towards a Unified Enterprise Modelling Language. *International Journal of Production Research*, 40(17):4309–4321., 2002. doi: 10.1080/00207540210159626.
- Hubert von Braun, Wolfgang Hesse, Urs Andelfinger, Hans-Bernd Kittlaus, and Gert Scheschonk. Conceptions are Social Constructs - Towards a Solid Foundation of the FRISCO Approach. In *ISCO*, pages 61–73, 1999.
- Yair Wand and Ron Weber. On the deep structure of information systems. *Information Systems Journal*, 5(3):203–223, 1995.
- Hans Weigand. Lap: 10 years in retrospect. In *International Working Conference on the Language-Action Perspective on Communication Modelling (LAP)*, Kiruna, Sweden, 2005.
- David A Whetten. What constitutes a theoretical contribution? *Academy of management review*, 14(4):490–495, 1989.
- Ilona Wilmont, Sjaak Brinkkemper, Inge van de Weerd, and Stijn Hoppenbrouwers. Exploring Intuitive Modelling Behaviour. In *BMMDS/EMMSAD 2010*, pages 301–313, 2010.
- Ilona Wilmont, Erik Barendsen, Stijn Hoppenbrouwers, and Sytse Hengeveld. Abstract Reasoning in Collaborative Modeling. In *HICSS*, pages 170–179. IEEE Computer Society, 2012. ISBN 978-0-7695-4525-7.
-

- Ilona Wilmont, Sytse Hengeveld, Erik Barendsen, and Stijn Hoppenbrouwers. Cognitive mechanisms of conceptual modelling - how do people do it? In *ER*, pages 74–87, 2013.
- T. Winograd and F. Flores. *Understanding Computers and Cognition - A New Foundation for Design*. Ablex Publishing Corporation, 1986.
- Petia Wohed, Wil M. P. van der Aalst, Marlon Dumas, Arthur H. M. ter Hofstede, and Nick Russell. On the Suitability of BPMN for Business Process Modelling. In *Business Process Management*, pages 161–176, 2006.
- B. Wyssusek. Ontology and ontologies in information systems analysis and design: a critique. In *AMCIS*, pages 4303–4308, 2004.
- B. Wyssusek, M. Schwartz, and B. Kremberg. The Philosophical Foundation of Conceptual Knowledge: a Sociopragmatic Approach. In *Supplementary Proceedings of the 9th Int. Conf. on Conceptual Structures*, pages 189–192, 2001a.
- B. Wyssusek, M. Schwartz, and B. Kremberg. Knowledge management: a sociopragmatic approach. In *Proceedings of the 2nd European Conf. on Knowledge Management, Bled, Slovenia*, pages 767–776, 2001b.
- B. Wyssusek, M. Schwartz, B. Kremberg, F. Baier, and Leicester UK. 2001. Krallmann, H.. In Leicester University. Business process modelling as an element of knowledge management: a model theory approach. In *Proceedings of the 2nd Int. Conf. on Managing Knowledge: Conversations and Critiques*, 2001c.
- B. Wyssusek, M. Schwartz, and B. Kremberg. Targeting the Social: A Sociopragmatic Approach Towards Design and Use of Information Systems. In *Information Resources Management Association Int. Conf.*, pages 832–835, 2002.
- Boris Wyssusek. Enterprise System Implementation and Linguistic Shaping of Organizational Knowledge. In *PACIS 2005 Proceedings*, 2005. Paper 33.
- Boris Wyssusek. On Ontological Foundations of Conceptual Modelling. *SJIS*, 18(1), 2006.
- Eric Yu. Towards Modelling and Reasoning Support for Early-Phase Requirements Engineering. In *3rd IEEE Int. Symposium on Req. Engineering*, pages 226–235, 1997.
- Z. Zarwin, M. Bjeković, J-M. Favre, J-S. Sottet, and H.A. Proper. Natural modelling. *Journal Of Object Technology*, 13(3):4:1–36, July 2014. ISSN 1660-1769. doi: 10.5381/jot.2014.13.3.a4. URL http://www.jot.fm/contents/issue_2014_07/article4.html.
- Srdjan Zivkovic and Dimitris Karagiannis. Towards metamodeling-in-the-large: Interface-based composition for modular metamodel development. In *EMMSAD 2015*, pages 413–428, 2015. doi: 10.1007/978-3-319-19237-6_26. URL http://dx.doi.org/10.1007/978-3-319-19237-6_26.
-

Michael zur Muehlen and Jan Recker. How Much Language Is Enough? Theoretical and Practical Use of the Business Process Modeling Notation. In *CAiSE*, pages 465–479, 2008.

Appendix

This Appendix provides the illustration of some of the instruments used in preparation and realisation of the interpretive field study in the thesis.

Anticipatory Data Reduction

Detailed Research Questions

Last modification date: 10.11.2015

Version id: v007

Notes for the version: Clearer distinction between modelling effort and context.

- What are the characteristics of the given enterprise modelling effort in which the selected modelling language is used?
- What are expected outcomes of modelling in the wider project context, and are there other relevant external factors affecting the modelling effort?
- What are the main factors that influenced the choice of a modelling language to use in a given enterprise modelling effort?
- If applicable, which alternatives were considered when choosing the modelling language? If some trade-off between the different alternatives had to be done, explain it and describe the criteria involved in this decision-making process.
- What are the relevant characteristics of the selected modelling language, and then also related to the selected tool?
- How is the modelling effort organised? What is the level of involvement and participation of the all parties involved as observer, what roles model

creators have? How is the communication achieved, and are there some rules for model development and evaluation?

- In the concrete modelling context, what are the participants taking role of observer in modelling, what is the targeted model audience and model purpose?
 - How is the model purpose influencing the modelling process?
 - Is the purpose explicitly considered, and what is its influence in different stages/streams of modelling?
 - How is the cost-effectiveness of the linguistic function of a selected modelling language in its use estimated by different parties in the role of observer?
 - Way of thinking - How does it influence the shaping of the domain, and its expression?
 - Way of thinking - Are different concepts otherwise used by the observer/participants to express the same domain within their domain of discourse?
 - Level of abstraction - Is the level of abstraction of modelling language adequate for the modelled domain?
 - Topical fitness - Are there topics/aspects that need to be covered, and are not covered by the modelling language?
 - How is the cost-effectiveness of the representational function of a selected modelling language in its use estimated by different parties in the role of observer?
 - Are the visual symbols rooted in the use, familiar to the observer (already existing interpretation in line with the language specification)?
 - Is the visual notation easy to visually process?
 - Is there a good alignment between visual symbols and abstract syntax?
 - Does the (selected/available) visual manifestation of the model on the medium allows for the model to meet its purpose?
 - What challenges with the modelling language used have occurred, and how are they addressed? Discuss trade-offs, options and decisions taken. Also the consequences of these decisions on the model and its value.
 - If the variant of the selected modelling language emerged through its use in the given modelling effort, what are the reasons, how is this variant manifested (mechanisms for language extension used)? How are these reasons and the variant manifestation in relation to the identified challenges in modelling?
-

- A posteriori evaluation of the observer (both model creators and if available, audiences) with regards to the role and the cost-effectiveness of the modelling language in the modelling effort?
- (Cross-case) Main factors affecting the language variations
- (Cross-case) Can the variants be further characterised

Initial Coding List

10.11.2015.		Code abbreviations/Label
Code description		
Selected modelling tool characteristics		SELECTED MODELLING TOOL CHARACTERISTICS
		SELECTED LANGUAGE CHARACTERISTICS
Visual notation aspects of the modelling language		ML-VISUAL NOTATION
Conceptual complexity of the modeling language		ML-CONCEPTUAL COMPLEXITY
Clarity of conceptual definitions in the language		ML-CONCEPTUAL CLARITY
Abstraction level of selected modelling language		ML-ABSTRACTION LEVEL
		NOTE
Surprises		NOTE-SURPRISE
Puzzles to follow up on		NOTE-PUZZLE
		MODELLING-ORGANISATIONAL-ASPECTS
Goals of the modelling effort besides creating the model		ME-OTHER GOALS
Other organizational aspects of the modelling effort		ME-ORG-OTHER ASPECTS
Documentation		ME-ORG-DOCUMENTATION
Communication within the modelling effort		ME-ORG-COMMUNICATION
Model version		ME-MODEL VERSION
		MODELLING-MANIFESTATION-STREAM
Implicit consideration of purpose		MANIF-PURPOSE-IMPLICIT
Explicit consideration of purpose		MANIF-PURPOSE-EXPLICIT
Modelling language in manifestation		MANIF-MODELLING LANGUAGE
Interpretation of visual symbols		MANIF-LANG-VISUAL SYMBOL INTERPRET
Visual structuring		MANIF-LANG-VISUAL STRUCTURE
Visualisation/notation related aspects		MANIF-LANG-VISUALISATION
Aspects related to the tool support quality		MANIF-LANG-VISUAL-TOOL QUALITY
Aspects related to the language notational quality		MANIF-LANG-VISUAL-LANGUAGE QUALITY
Structuring of the domain model		MANIF-DOMAIN-STRUCTURING
		MODELLING-EVALUATION-STREAM
Rules and procedures of evaluation		EVAL-RULES PROCEDURES
Evaluation of model's purposefulness		EVAL-MODEL-PURPOSEFULNESS
Considerations relevant for language		EVAL-LANGUAGE-PURPOSEFULNESS
		MODELLING-CONTEXT

Figure 1: Initial coding list, page 1/3

Observer in modelling context	MC-OBSERVER
Passive audience of model	MC-PASSIVE-AUDIENCE
Observer's experience with modelling language	MC-OBSERVER-LANG-EXPERIENCE
Involved model audience	MC-INVOLVED-AUDIENCE
Intended model audience	MC-INTENDED-AUDIENCE
Creator of model	MC-CREATOR
Role of models in the project	MC-MODEL-ROLE
Role of modelling effort in the project	MC-MODEFFORT-ROLE
Expected outcomes	MC-MODEFFORT-OUTCOMES-EXPECTED
Intended use of model	MC-INTENDED-USE
Model's creator's understanding of the intended model use	MC-INTENDED-USE-CREATOR
External influences	MC-EXT-INFLUENCE
Description of the modelling context	MC-DESCRIPTION
	MODELLING-ABSTRACTION-STREAM
Implicit consideration of purpose	ABS-PURPOSE-IMPLICIT
Explicit consideration of purpose	ABS-PURPOSE-EXPLICIT
Modelling language related considerations	ABS-MODELLINGLANGUAGE
Language in domain framing	ABS-LANGUAGE-DOMAINFRAMING
Language abstraction level influence	ABS-LANG-ABSTRACTIONLEVEL
Challenges to using language	ABS-LANG-CHALLENGES
Partially adequate abstraction for the domain	ML-ABS-PARTIALLYGOODABSTRACTION
Ambiguity of language concepts	ABS-LANG-AMBIGUOUSCONSTRUCTS
Topical coverage of language	ABS-LANG-TOPICALCOVERAGE
Missing concepts	ABS-LANG-MISSINGCONCEPTS
Missing aspects	ABS-LANG-MISSINGASPECTS
Compensatory strategies	ABS-LANG-COMPENSATORYSTRATEGY
Reduced set of language used	ABS-LANG-REDUCEDSET
Renegotiation of concept definition	ABS-LANG-CONCEPTSRENEGOTIATED
Framing of domain	ABS-DOMAIN-FRAMING
Sources of domain framing	ABS-DOMAIN-FRAMING-SOURCES
Conceptual negotiation in domain framing	ABS-DOMAIN-FRAMING-CONCEPTUALNEGOTIATION
Domain delimitation	ABS-DOMAIN-DELIMITATION
Challenges of domain delimitation	ABS-DOMAIN-DELIMITATION-CHALLENGE
Agreement on domain delimitation	ABS-DOMAIN-AGREEMENT
	LANGUAGE VARIANT
Reasons for the variant	ML-VARIANT-REASON
Causes in representation function	ML-VARIANT-CAUSE-RF

Figure 2: Initial coding list, page 2/3

Causes in linguistic function	ML-VARIANT-CAUSE-LF
Language variant manifestation	ML-VARIANT-MANIFESTATION
Applied workarounds	ML-VARIANT-WORKAROUNDS
Workaround to resolve concept ambiguities	ML-WORKAROUND-USE-AMBIGUOUS-CONSTRUCTS
Tags used as a workarounds	ML-WORKAROUND-TAGS
Reuse of visual structuring in the language variant	ML-VARIANT-REUSE-VISUAL-STRUCTURE
Modification of visual structuring in the language variant	ML-VARIANT-MODIFIED-VISUAL-STRUCTURE
Modification in the problem structuring	ML-VARIANT-MODIFIED-PROBLEM-STRUCTURING
Extended the existing domain framing	ML-VARIANT-EXTENDED-DOMAIN-FRAMING
Use of extension mechanisms for defining variant	ML-VARIANT-EXTENSION-MECHANISM
	LANGUAGE SELECTION FACTORS
Trade-offs	ML-CHOICE-TRADEOFFS
Factors of representation/notation	ML-CHOICE-REPRESENTATIONASPECTS
Other languages considered	ML-CHOICE-OPTIONS-CONSIDERED
Close to the usual way of thinking by the observer	ML-CHOICE-OBS-WAYOFTHINKING
Model purpose as a factor of choice	ML-CHOICE-MODELPURPOSE
Factors external to modelling effort	ML-CHOICE-EXTFACTORS
Adequacy for the domain modelled	ML-CHOICE-DOMAINADEQUACY
Modelling tool availability	ML-CHOICE-AVAILABLETOOL
	LANGUAGE DIALECTISATION FACTORS
Representation function	LANG-DIALECT-RF-FACTORS
Interpretation of visual symbols	DIALECTISATION-VISUALSYMBOLINTERPRETATION
Optimisation for visual processing	DIALECTISATION-VISUALPROCESSING
Alignment with abstract syntax	DIALECTISATION-LS-RS-ALIGNMENT
Linguistic factors	LANG-DIALECT-LF-FACTORS
Way of thinking	DIALECTISATION-WAYOFTHINKING
Topical fitness	DIALECTISATION-TOPICALFITNESS
Conceptual complexity related	DIALECTISATION-CONCEPTUALCOMPLEXITY
Conceptual clarity related	DIALECTISATION-CONCEPTUALCLARITY
Abstraction level	DIALECTISATION-ABSTRACTIONLEVEL

Figure 3: Initial coding list, page 3/3

Data Collection

Initial Data Collection Plan

Last modification date: 20.10.2015

Context analysis

- Understand the project and the role of modelling within the project
- Use documentation, interviews with project leaders and relevant participants
- Follow up on the eventual changes in the project objectives, roles of the models, new circumstances etc.

Core data collection

- Ideally recording of modelling sessions, ideally, but this will depend on the day I embark on the project, the number of participants and the available time. No transcriptions verbatim, mainly notes and some citations. Re-listen the recordings however.
- Model walk-through sessions after the following of the evolution of model versions and situation with the language. Each new session to be based on the performed analysis, and identification of missing data. In the later stages, new data collection waves will more and more target the explanations and findings testing.
- Document analysis – all the modelling documentation, including the notes of modellers, if available
- Artefact analysis – model, language

Model and language use

- Follow the development of different versions of the model. Analyse models. Take the stable version, and analyse the models, the documentation at three levels:
 1. Domain of discourse: What concepts to use, which concepts exist and are relevant in the given domain, taking into account the entire modelling context and purpose. Observe how this discussion evolves during the modelling, and given the different purposes of modelling.
 2. Metamodel level: How to express the domain of discourse with the meta-concepts of the selected modelling language, what obstacles are there, and how they are coped with.
 3. Evaluation-level: Relation of these two flows of discussions with the evaluation of model's fitness for purpose.
-

- After each analysis, get into the contact with the team and main modellers, in case needed other stakeholders as well, and discuss open issues, ask questions, ask explanations and clarifications. In general, take notes and have the recording of these sessions (aka model walk-through sessions).
- Several rounds like this until the data analysis can be deepened enough to be able to point at the key explanations, and re-evaluate them in one of the last collection plans

Interview Preparation Notes Example

Last modification date: 23.4.2015.

Interview date: 28.4.2015.

Based on the following documents:

- Document summaries:
 - Domain model v1.0 summary,
 - Domain model v1.1 summary,
 - Domain model v1.2 summary,
 - Sectorial metamodel v0.5 summary
- Memos
- Notes

Questions for the interview organised in topical groups

Actors and roles in the project

It is rather for me to clarify. Ask the team if there are any changes with the participants and their involvement.

Overall organisation of the modelling effort

1. Reflections and strategy of modelling
 - 1.1. What is sectorial metamodel essentially? General metamodel for structuring, dialect of Archimate and documentation of the way of seeing the sector, while following its philosophy in domain modelling only? Is it meant to be a normative reference for health sector modelling in any future?
 - 1.2. What is going to be its relation with the ArchiMate metamodel?
2. Relationship between ‘metamodel’ and domain model
 - 2.1. To which extent is the proposed ‘way of thinking’ contained in the metamodel followed in the domain model?

- 2.2. To which extent is the structure followed in the domain modelling?
3. Relationship between the domain model and security-risk analysis models
 - 3.1. How does it fit in the current story?
 - 3.2. What is the progress there with the security part of the team?
 - 3.3. How does it connect with the current modelling exercise?
 - 3.4. A general note: Soon there will be the need to express the business rules, those rules related to the security, or to indicate the risks. Are you going somehow to introduce them in the Archimate diagrams, or in some other model? What are your reflections and considerations? And how the platform of Ministry influences this decision?
4. Integration platform and sectorial risk model
 - 4.1. Expectations, current state, planning

Domain model v1.0 to v1.2

Modelling context

1. Apart sectorial comprehension for the internal purposes of the modelling team, is someone else involved in validating and evaluating of the model fitness for purpose?
2. Apart from being used for the input for sectorial risk analysis, does it need to be used for something else ?
3. Requirements wrt to domain modelling
4. Present sectorial actors, their exchanges of information at 2 levels (sector-level and zoom to actors)
5. Keep service-orientation in the sectorial metamodel
6. Focus on outsourced services in particular, because of security risks only?

General approach and concepts

1. Current status wrt the distinction between Capability vs Process vs Function vs Service, and if there is any other issue being in discussion/unresolved.
2. Current status wrt the separation between Actors vs Role, and if there is any other issue being in discussion/unresolved.

Organisation of the model

- Sectorial-level views: represent the information about the sector, seen as holistic. system overview (i.e. healthcare sector overview), and healthcare actors, healthcare information and healthcare services views (viewpoints?)
-

- System overview, healthcare actors:
 1. Why do you have HealthcareActor, HealthcareRole terms at this level, and not at the level of what you want to be sectorial meta-model?
 2. Is the actor in the role of abc only providing services, should the assignment be between the role and the service?
- Healthcare information view:
 1. Is the various information represented in business objects in this view supposed rather to be aggregated/compositional elements of the healthcare information? Or its specialisations? Why is not that modelled? How is this related to the comment inserted in this view (about levels of data representation)?
 2. Explain the comment put in this view.
- Actor-specific views:
 1. There seems to be the link between the abstraction saved in the sectorial metamodel and the choice of views for laboratories, their concepts and structure. Could you comment on this?
 2. (For me) However, it seems that the Operation layer is not explicitly represented in the Sectorial Metamodel. It seems that implicitly the relation between the layer in the Sectorial metamodel roughly corresponds to the viewpoint of the laboratory as the actor in the sector: we find its capabilities, operations, technology and the key capabilities detailed.

Laboratory portion (versions v1.1 and v1.2)

Organisation

1. What is the objective of the lab portion of the model?
2. What is the projected audience of that part of the model being developed?
3. What is the role of the laboratories in the process? Is the feedback of these actors simply limited to providing the information and not to validating the model? Are they anyhow concerned by the resulting model?
4. What kind of expectations do they have wrt to the model?
5. What is your reflection about the level of detail you would like to bring about in defining capabilities?

Laboratory capabilities view

1. Link between the services (or processes) and capabilities, as well as between services/capabilities and actors/roles is missing. What is the underlying rationale? How are the services connected to the actors?
-

2. BF construct is used to model capabilities or functions? What is the meaning underlying the visual symbol and how does this relate to the sectorial metamodel?
3. A general remark for the detailed modelling of capabilities. In case, in particular, of the Examination capability: Is there any, even not precise, ordering in activities within the Capability? If yes, why not model this as process?
4. Capability vs Function - Did you not decide to use BF construction to model capabilities. And what is modelled here with BF seem to be capabilities. The link between the modelled capabilities is meant to be aggregation/composition, right? How is the tool processing this?

Laboratory technology view

- Services composition

Laboratory full view (and Laboratory services/functions)

1. Where is the laboratory as the actor or role here at the diagram?
2. How are these packages related to the identified layers at the sectorial metamodel?
3. Are the Function metier, support function and management functions rather meta-concepts? Also, are these introduced only for the grouping purposes? Why are these distinguished? Is the link between the contained capabilities really meant to be like this?

Sectorial metamodel v0.5

1. Who works on the metamodel?
 2. Objectives, intentions and purposes of the sectorial metamodel v0.5? Seems to be intended as:
 - (a) Linguistic framing of the way of thinking about (any) sector
 - (b) Way to conceptually structure the complexity at this level of abstraction
 - (c) Sector-specific? Or just a general philosophy, or general ontological view of structuring sectors? It seems too generic. the only two concepts that seem more health-oriented are those of Instrument and Facility.
 3. Relationship between the sectorial metamodel and domain model?
 4. The intended usage of the sectorial metamodel, as well as the audience.
 5. Detailed questions about the modelling choices
 - (a) Layering in the sectorial metamodel to be discussed.
-

- (b) Service Delivery process and link with the organisation capability - (trigger or used by?)
- (c) What are Business service engagement, provision, compensation? and how are they defined? Why modelled as services?
- (d) Explain the principle “Taking service forward”.
- (e) Is the link towards outsourced service rather at the level of the business service?
- (f) The capabilities: Is the link between these capabilities meant to be composition/aggregation?
 - What is the point of modelling capabilities and plateaus ?
 - Why are the application functionalities modelled as capabilities?

6. Potential problems:

- Service Layer - The use of Role and Actor meta-concepts
- Resource Layer - Use of the same constructs for modelling Competence (role) and employee (actor) so how do you plan to distinguish between these two different uses? only according to the layers?

7. Reflection on “meta-modelling” and ArchiMate as the metamodel used in this exercise

- This ‘way of thinking’ about the sector is something like service system, so why using again the ArchiMate language? What is the added value for you - the visualising aspect? the analysis potentially enabled by the tool...?
- Here, the modellers also redefine the layers, which are not anymore EA (limited to only an enterprise), but sectorial-EA like layers. So, clearly, a different domain framing than proposed by the EA modelling language.

Various reflections

1. Any problems/challenges in modelling aspects of the domain with ArchiMate, that we missed to discuss.
2. Role of the model management platform and details about this platform.

Examples of Models Produced

Model: Health modelling v0.9
Last modification date:28.11.2014.

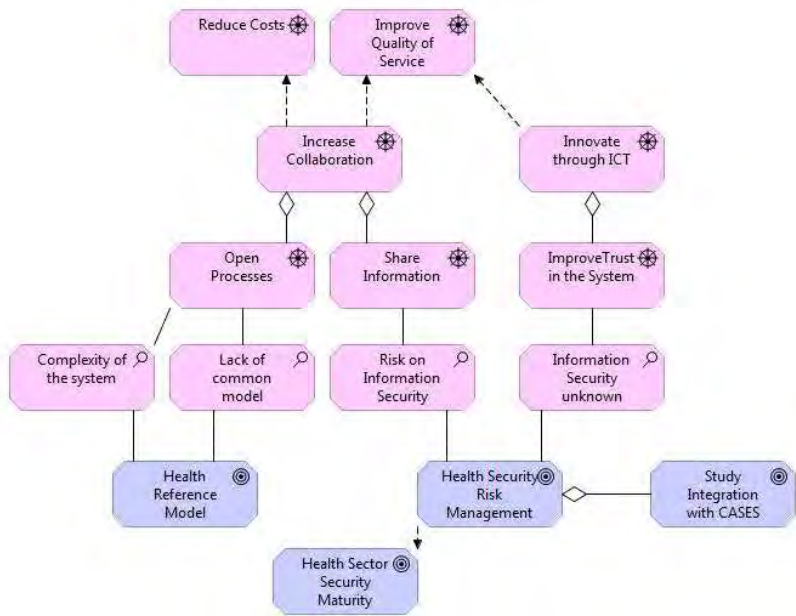


Figure 4: Business Challenges

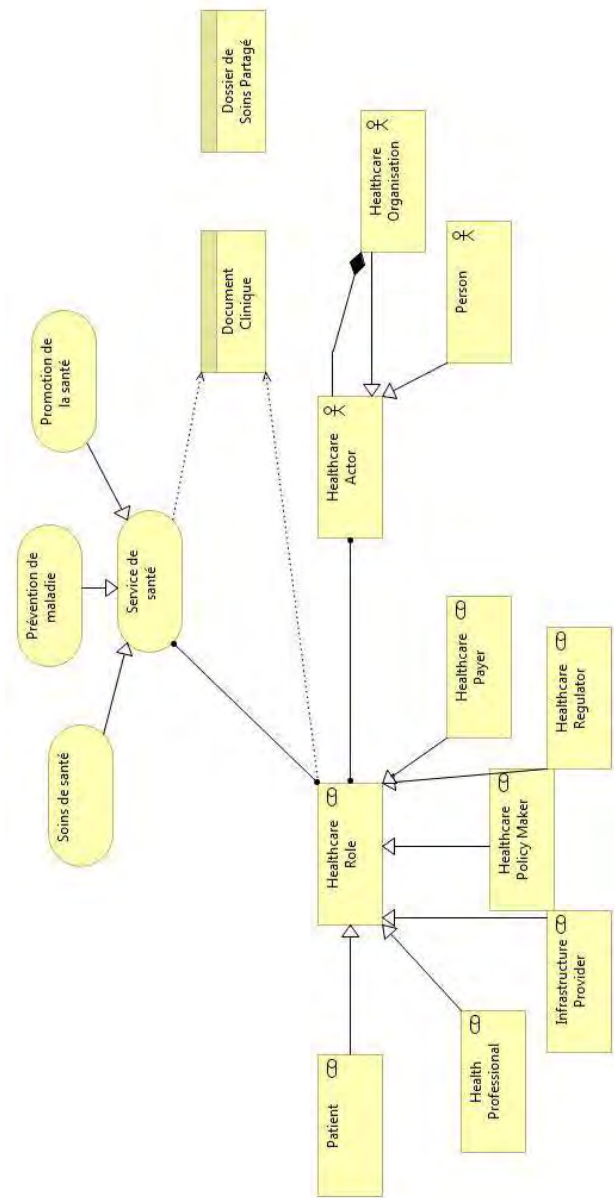


Figure 5: Business Overview

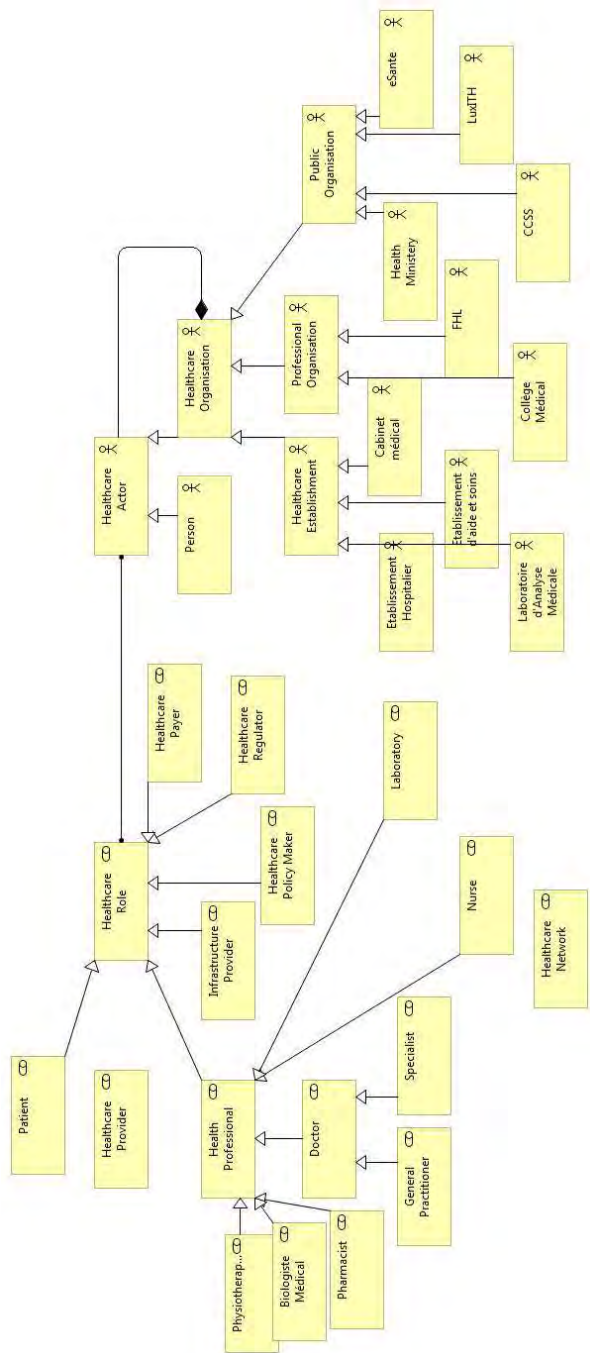


Figure 6: Healthcare Actors view

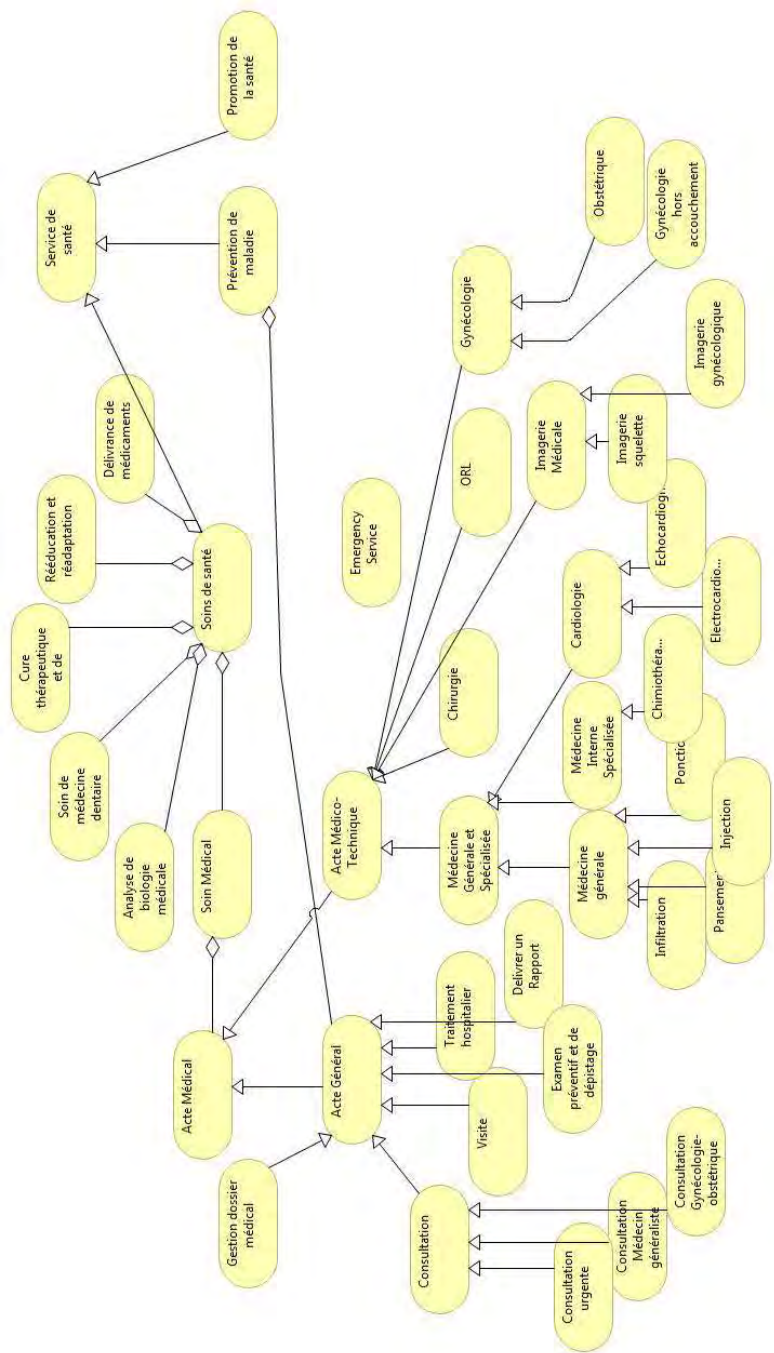


Figure 7: Healthcare Services view

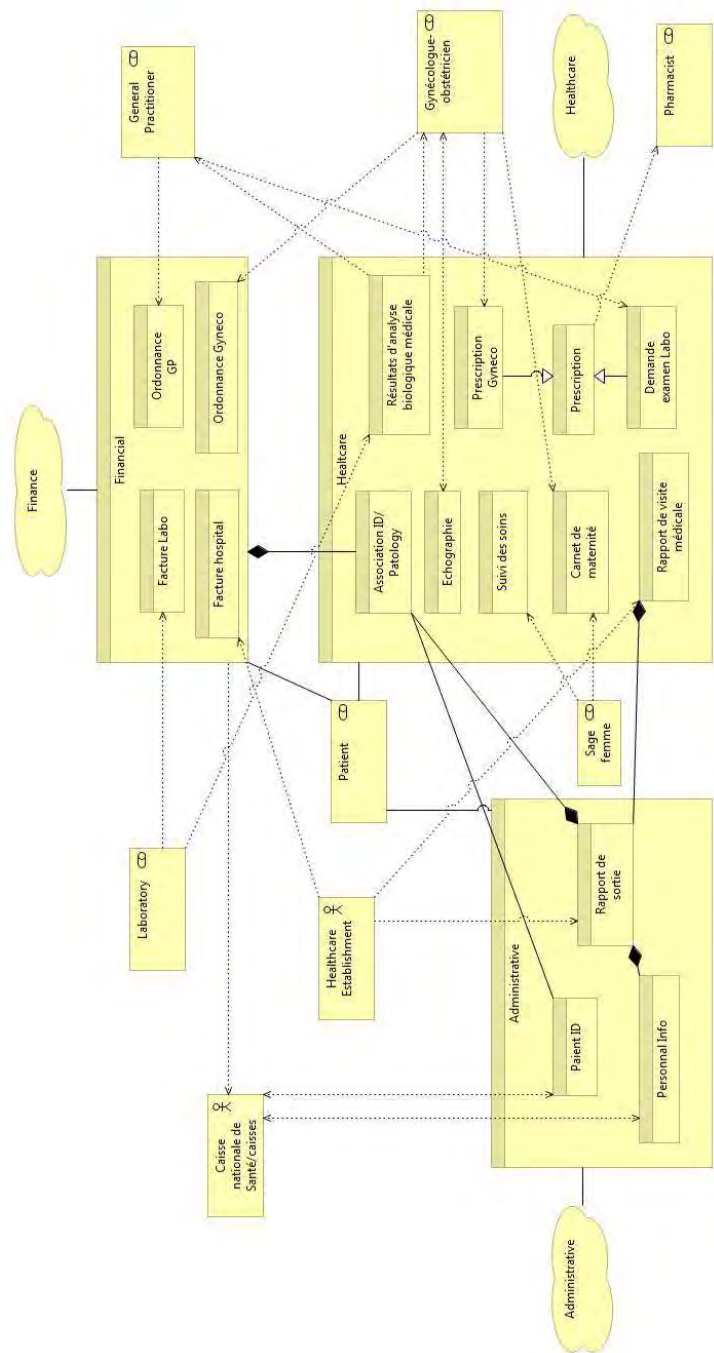


Figure 8: Information for Health view

Data Analysis Instruments

Model Version Summary Examples

Domain model v07-v09 and its views

Date retrieved: 13.11.2014. – 28.11.2014

Context (what it is related to):

Domain analysis. Purpose is to understand the health sector, identify actors and services, to know well the network of actors around which the security risks are to be identified.

The observers at this point are only the modellers, both on the sectorial and risk analysis level. Some initial feedback from [anonymous] which is the end user of the models.

Based on this initial modelling, the scoping will be done once the purpose is fully understood.

DSP is an electronic patient record, and its representation is based on the definition of agency e-Santé, who defined the structure of DSP for Luxembourg.

At this point, the modelling effort still suffers from the lack of involvement of stakeholders, needed for understanding the domain and identifying relevant risks related to the core of their activity.

Summary:

Created in the initial stages of modelling in the project. Without the involvement of the domain actors.

Domain framing in terms of Actors, their roles, and the exchange of Services and Information between the actors.

Actors and Services modelled according to the CNS nomenclature, but the question of level of details of services pops up.

The initial structure of the sector as a whole is only core, will probably not be further refined. Not core of the problem anyway. Then, initial understanding of the business of one actor, targeted in the project, is done.

The problem of the distinction of Actors and Roles is already present here, at the holistic level of modelling.

The Laboratory as actor has been chosen as the most accessible and also the actor whose activity in the sector is the most structured and the most

regulated. Help of [anonymous] people in reaching the health care actors.

When descending in the initial modelling of the Laboratory actor, the problem of interpretation of the Business Service notion is present, the right level of detail as compared to the CNS nomenclature.

At the same time, the relationship between the Business Service and Business Process is also surfacing.

Lastly, apart from the role and actor distinction, the relationship between the Service and the Actor is investigated. The team wants these to remain in the direct relationship, as the Actor and not the role has the direct contractual responsibility for the service.

Furthermore, the domain model v0.7 and v0.8 already reflect the twofold possible interpretation of the Role concept in ArchiMate in the context of their modelling. Roles can be nominated roles of Actors within the sector, but can also be used to represent the internal sets of competences in the organisation.

Importance/significance:

In this modelling stage, the reflection on the value and use of ArchiMate, its level of abstraction, its philosophy have been performed, as well as the interpretation and refinement of certain meta-concepts for this modelling effort has been starting.

First challenges are emerging.

Notes:

Identified challenges with the metaconcepts

Keep track of reflection on Actor-Role., Business Process-Service, Business Function and Capability, as well as the solution for the outsourcing.

Keep track of the levels of abstraction adopted, the use of mechanisms of viewpoints, the importance of structuring of the domain in a particular way.

Laboratory model v1.4.

Date retrieved: 18.11.2015

Date last update of v1.4: 20.08.2015

Context (what it is related to):

Importance:

Resolved issue with the Process and Service meta-concepts, no longer used in modelling.

Furthermore, the Packages are used to reflect the alignment with the metamodel.

The framing of Capabilities as well as their manifestation seem now to be stable: 1) I location, capability, information, internal roles and IT support are present for each diagram detailing the capability.

Services-Functions view no longer existing.

Changes in IT modelling.

Summary:

- There seems to be the refinement of the model, in terms of its closer alignment/conformance with the sectorial metamodel. For instance, in all Laboratory Process diagrams, the supporting and management functions, previously in v1.2 modelled as functions, now are only packages, which is also the approach adopted in Sectorial Metamodel.
- Supporting capabilities are refined, and their separate diagrams are modelled, including both information, business and infrastructure-related aspects. The structured and the framing is refined here: there is location, business functions, no processes, roles, informations and IT support being modelled for each relevant Capability. This seems to reflect the coverage per capability which is needed for risk analysis, most probably.
- Only the internal roles are modelled. No twofold modelling of Roles at the level of an Actor detailed models.
- Process and Service concepts fully removed from the model.

No longer the use of view Services-Functions. !!!

IT modelling:

LIMS is LIS now. Separate diagram to model internal structure of components of the LIS application, and not to have it on the whole view of IT.

Questions and other remarks:

- All the process diagrams (pre analyse, analyse, post analyse) are refined, information and IT layers concepts added. What has driven the inclusion of all these details, potential impact of risk analysis needs?
- Any clarification with regards to the purpose of the model, and the influence of risk analysis on it?
- Information regarding applications is being refined. Laboratory technology refined, all these data are probably referred to in other detailed diagrams?
- In Lab technology view, an Actor and not Role is related to the applications. Why?
- New views: detailed modelling of application LIS. LIS = LIMS?
- The solution adopted for the outsourcing of certain aspects of the business, certain capabilities?
- The clear distinction actor and role.
- Capability = Function seems to have stayed as the solution.
- Process concept has fully been removed. Service also.
- It also seems that the holistic views (overview, actors, information and services) do not vary anymore across the versions. Am I right?
- What is the purpose of the view Laboratory environment?

Notes:

Sectorial metamodel v0.5

Date retrieved: 19.11.2015

Date last modified: 20.10.2015

Objectives, intentions and purposes of the sectorial metamodel v0.5:

Summary:

Intentions underlying the decision to create this "metamodel": This seems to be as clearly intended as the metamodel to frame the general thinking about the sector, i.e. the level of abstraction and the concepts to speak about the sector-level scenarios.

How specific it is to the health sector? It seems very generic. the only two concepts that seem more health-oriented are those of Instrument and Facility.

Relations with the domain modelling: How is it connected to the domain model v1.0 and further versions of the domain model?

Relationship with ArchiMate metamodel: It seems to me that what they call sectorial metamodel is a first trace of the 'divergent' or 'dialect-like' way in which they use the Archimate language. It seems to me that this metamodel incorporates and documents some of the modelling/abstraction/way of seeing the 'domain' that the people on the project deem needed in their sectorial scenario.

This 'way of thinking' about the sector is something like service system. But they need to be able to also look internally into the actor's processes. While ArchiMate allows a layering structure to model internal aspects of the organisation, it misses the concepts for modelling value networks, aka service systems, so it seems that this is what the modellers aim to cover with the sectorial metamodel.

Maybe the added value of ArchiMate here is only in the way it structures and allows to visualise the elements of the model. Additionally, it may also be the system of viewpoints that they need and is available in ArchiMate and tools that support it.

Here, the modellers also redefine the layers, which are not anymore EA(limited to only an enterprise), but sectorial-EA like layers. So, clearly, a different domain framing than proposed by the EA modelling language.

Reflections

- Service Delivery process - (trigger or used by?) - link with organisation capability.

- What are Business service engagement, provision, compensation? and how are they defined? Why modelled as services?
- Explain the principle “Taking service forward”.
- Is the link towards outsourced service rather at the level of the business service?

Potential problem:

- Service Layer - Use of Role (sectorial role) and Actor (stakeholder) constructs
- Resource Layer - Use of the same constructs for modelling Competence (role) and employee (actor) so how do you plan to distinguish between these two different uses? only according to the layers?

Notes:

Especially look at the motivations of all the updates.
Check to which extent has the conformance with the domain models been intentional.

Final Coding Scheme

10.04.2017.	Code description	Code abbreviations/Label
		ABSTRACTION-STREAM
	Process aspects	ABS-PROCESS-ORIENTED
	Agreement on domain delimitation	ABS-DOMAIN-AGREEMENT
	Framing of domain	ABS-DOMAIN-FRAMING
	Sources of domain framing	ABS-DOMAIN-FRAMING-SOURCES
	Domain delimitation in relation to purpose	ABS-DOMAIN-TOPICAL-FITNESS
	Challenge of domain delimitation	ABS-DOMAIN-DELIMITATION-CHALLENGE
	Consideration of purpose	ABS-PURPOSE-CONSIDERED
	Explicit	ABS-DOMAINFRAMING-PURPOSE-EXPLICIT
	Implicit	ABS-DOMAINFRAMING-PURPOSE-IMPLICIT
	Consideration of purpose specifically in domain delimitation	ABS-DOMAIN-TOPICS-PURPOSE-EXPLICIT
		EVALUATION-STREAM
	Process of evaluation	EVAL-PROCESS
	Rules and procedures of evaluation	EVAL-RULESPROCEDURES
	Consideration of purpose	EVAL-PURPOSE
	Considerations relevant for language	EVAL-LANGUAGE-PURPOSEFULNESS
	Level of detail of the model for the purpose	EVAL-LEVEL-OF-DETAIL
	Evaluation of model's purposefulness	EVAL-MODEL-PURPOSEFULNESS
	Demonstration pilot study that approach works	DEMONSTRATION-PILOT-STUDY-MODEL-ENABLED
	Explicit evaluation of model's purposefulness	EXPLICIT
	Implicit evaluation of model's purposefulness	IMPLICIT
		LANGUAGE USE FACTORS
	Benefits of using Archimate	BENEFIT
	Linguistic-function related	LF-FACTORS
	Conceptual organization	CONCEPTUAL ORGANISATION
	Conceptual granularity	CONCEPTUAL GRANULARITY (LEVEL OF DETAIL)
	Inner structuring	INNER STRUCTURING
	Conceptual perspective related	CONCEPTUAL PERSPECTIVE
	Focus	FOCUS
	Core concepts	CORE CONCEPTS
	Topical coverage	TOPICAL COVERAGE
	Representation function related	RF-FACTORS
	Alignment with abstract syntax	LS-RS-ALIGNMENT
	Viewpoint mechanisms	MECHANISM-VIEWPOINT

Figure 9: Final coding list, page 1/6

Capitalisation of the way of thinking across projects	CAPITALISE-WAYS-OF-THINKING-PROJECTS
Costs in use of Archimate	COST
Linguistic function related	LF-FACTORS
Conceptual organisation	CONCEPTUAL ORGANISATION
Ambiguity in concepts and relations	AMBIGUITY
Lack of guidance of how to use some constructs	LACK OF CLEAR APPROACH
Problem with layering – redundant constructs for same thing	LAYERING-MECHANISM-AS-PROBLEM
Relations are possible in all ways	MANY-RELATIONS-POSSIBLE
Granularity	GRANULARITY
Inner structuring	INNER STRUCTURING
Conceptual perspective	CONCEPTUAL PERSPECTIVE
Core concepts	CORE CONCEPTS
Focus	FOCUS
Topical coverage	TOPICAL COVERAGE
Representational function related	RF-FACTORS
Implementation of dialect is not available	LACK-OF-IMPLEMENTATION-SPECIALISED-LANGUAGE
Other factors	OTHER-FACTORS
Explicit trade-off in the use of language (assessment language value)	TRADE-OFF-IN-LANGUAGE-USE
	LANGUAGE SELECTION FACTORS
Linguistic function related	LF-FACTORS
Abstraction level	ML-ABSTRACTION-LEVEL
Concepts and their organization in layers	ML-CONCEPTUAL-ORGANISATION
Core concepts for EM	ML-CORE-CONCEPTS
Trade-offs	ML-CHOICE-TRADEOFFS
Other factors	OTHER-FACTORS
Capitalize on the existing knowledge embedded in language	CAPITALISE-AND-REUSE-EXISTINGKNOWLEDGE-LANGUAGE
Existing expertise with the modelling language	EXISTING-ORG-EXPERTISE
Learn limits of the language	LEARN-LIMITS-OF-LANGUAGE
Existing tools where language is implemented	MODELLING-TOOL-IMPLEMENTEDLANGUAGE
Political influences in the organization	POLITICAL-FACTOR-STANDARD
Representational function related	RF-FACTORS
Coherence between viewpoints	ML-CHOICE-COHERENCE-VIEWPOINTS
	MANIFESTATION-STREAM
Process-related	MANIF-PROCESS-ORIENTED
Challenges relative to model manifestation	MANIF-CHALLENGES
Structuring of the domain	MANIF-DOMAIN-STRUCTURING
Refinement details	MANIF-REFINEMENT-DETAILS

Figure 10: Final coding list, page 2/6

Consideration of purpose	MANIF-PURPOSE
Explicit consideration of purpose	MANIF-PURPOSE-EXPLICIT
Implicit consideration of purpose	MANIF-PURPOSE-IMPLICIT
	MODELLING DECISIONS
Modelling of laboratories	LABOS-MODELLING
Applications layer	APPLICATIONS
Keep Service orientation in IT layer	KEEP-SERVICEORIENTATION-IN-IT-LAYER
Business layer	BUSINESS
Alignment with industry reference models	ALIGNMENT-WITH-INDUSTRY-REFMODELS
Functional decomposition principle	FUNCTIONAL-DECOMPOSITION
Process realizes Services	PROCESS-REALISATION-OF-SERVICE
Modelling of resources	RESOURCE-MODELLING
Rules for identifying Capability	RULES-FOR-CAPABILITY-IDENTIFICATION
Infrastructure layer	IT
Visualisation of IT device	DEVICE-VISUALISATION
Relevance of the scope of IT models	IT-MODELLING-SCOPING-RELEVANCE
Scope of the sectorial model	SECTORIAL-MODEL-FRAME-SCOPE
Framing sector	FRAMING-SECTOR
Core structure of the sectorial model	CORE-SECTORIALMODEL-STRUCTURE
Holistic sectorial modelling framing in terms of concepts	HOLISTIC-SECTOR-FRAMING
Reference level of sector modelling	REFERENCE-MODELLING-SECTOR
Integration of reference model with risks	INTERGATION-REF-MODEL-RISKS
Do not be constrained by risk perspective in sector modelling	NOT-BE-CONSTRAINED-BY-RISK-PERSPECTIVE
Modification of ArchiMate's layering philosophy	LAYERING-PHILOSOPHY-MODIFICATION
Capability and Resource as layers	CAPABILITY-RESOURCE-LAYERS
Service and Capability as layers	SERVICE-CAPABILITY-LAYERS
Modelling service outsourcing	SERVICE-OUTSOURCING-PHILOSOPHY
Model organization	MODEL-ORGANISATION
Branching the model per actor type	BRANCHING-PER-ACTOR-TYPE
Keep coherence between holistic and actors-specific models	COHERENCE-INTENTION-HOLISTIC-Vs-ACTORSPECIFICVIEW
Specific ArchiMate use (Dialect-related decisions)	SPECIFIC-ARCHIMATE-USE
Added value of ArchiMate	ADDED-VALUE-ARCHIMATE
Make explicit decisions about how ArchiMate is used/modified	MAKE-EXPLICIT-USE-OF-ARCHIMATE
Reinterpretation of some ArchiMate concepts	META-CONCEPTS-INTERPRETATION
Actor use	ACTOR-USE
Application Component use	APPLICATION-COMPONENT-USE
Application Function use	APPLICATION-FUNCTION-USE
Application Service use	APPLICATION-SERVICE-USE

Figure 11: Final coding list, page 3/6

Business Function use	BUSINESS-FUNCTION-USE
Business Object use	BUSINESS-OBJECT-USE
Business Process use	BUSINESS-PROCESS-USE
Business Role use	BUSINESS-ROLE-USE
Business Service use	BUSINESS-SERVICE-USE
Device use	DEVICE-USE
Package use	PACKAGE-USE
Product use	PRODUCT-USE
Relationship between Service and Actor	SERVICE-ACTOR-RELATION
Alignment between sectorial model and defined dialect	MODEL-METAMODEL-ALIGNMENT
Process of defining ArchiMate dialect	PROCESS-OF-DEFINING
How team characterizes the variant	VARIANT-CHARACTERISATION
Important reflection on ArchiMate	VERY-IMPORTANT-ARCHIMATE-REFLECTION
	MODELLING PROCESS
Evaluating the way of thinking	EVAL-WAYOFTHINKING
Interaction with the risk modelling team	INTERACTION-RISK-TEAM
	MODELLING-CHALLENGES
Modelling of laboratory actor	LABOS-MODELLING
Application layer	APPLICATIONS-LAYER
How to model applications – constructs and level of detail	APPLICATIONS-MODELLING
Business layer	BUSINESS-LAYER
Needed the separation between capabilities and resources	CAPABILITY-RESOURCE-SEPARATION-NEEDED
Granularity of health services	HEALTH-SERVICE-GRANULARITY
Problems with process-oriented framing at business layer	PROCESS-ORIENTED-FRAMING
Resource concept lacking in ArchiMate	RESOURCE-CONCEPT-LACKING
Actor roles in the sector definitions	ROLE-OF-THE-ACTOR-DEFINITION
Role or Actor to be related with Service?	ROLE-OR-ACTOR-WITH-SERVICE
Technologies layer	TECHNOLOGIES-LAYER
Representing devices used in Labs	DEVICE-REPRESENTATION
What is IT resource	IT-RESOURCE
How to represent system software in ArchiMate	SYSTEM-SOFTWARE-REPRESENTATION
Related to the process of modelling	PROCESS-RELATED
Modelling at sectorial level	SECTORIAL-LEVEL-MODELLING
	ARCHIMATE-REALTED
	DISTINCTION-INSTANTIATION-CONFORMANCE
M	
Distinction between instantiation and conformance between MM and	
Adequacy of ArchiMate to model value networks	VALUE-NETWORK-MODELLING-ARCHIMATE

Figure 12: Final coding list, page 4/6

Integration between sectorial model and risk perspective	INTEGRATION-REFMODEL-AND-RISK-PERSPECTIVE
Identification of (risk-related) assets	ASSET-IDENTIFICATION
Involvement of sectorial actors	INVOLVEMENT-SECTORIAL-ACTOR
Alignment between roles and roles from IT perspective	IT-ROLE-ALIGNMENT
Level of detail of sectorial model for risk analysis	LEVEL-OF-DETAIL-FOR-RISK-ANALYSIS
Alignment between risk-view on resources and health-domain resource	RESOURCE-ALIGNMENT-RISK-HEALTH
	OUTSOURCING RELATIONSHIPS
How to incorporate variability in the reference model	INCORPORATE-VARIABILITY-IN-REFMODEL
How to model outsourcing relationships	SERVICE-OUTSOURCING-MODELLING
What is the core of the sector-level perspective	SECTOR FRAMING
	MODELLING-CONTEXT
Intended domain	MC-INTENDED-DOMAIN
Intended use of model	MC-INTENDED-MODEL-USE
Integration with risks perspective	INTEGRATIONWITHRISKS
Observer in modelling context	MC-OBSERVER
Main stakeholder changing role	CHANGING-ROLE-OF-MAIN-STAKEHOLDER
Creator of model	MC-CREATOR
Intended audience of model	MC-INTENDED-AUDIENCE
Involved model audience	MC-INVOLVED-AUDIENCE
Observer's experience with modelling language	MC-OBSERVER-LANG-EXPERIENCE
Prior experience with language	OBS-LANG-PRIOR-EXPERIENCE
Prior training in use of ArchiMate	OBS-LANG-TRAINING
Passive audience involved	MC-PASSIVE-AUDIENCE
Expected outcomes of modelling	MC-OUTCOMES-EXPECTED
	MODELLING-WIDERCONTEXT
Role of modelling effort in the project	ME-MODEFFORT-ROLE
Role of models in the project	ME-MODEL-ROLE
Other goals of modelling effort	ME-OTHERGOALS
Capitalise way of thinking "as a service"	CAPITALISE-aas-THINKING
Cross-project alignment in terms of modelling approach	CROSS-PRJECT-ALIGNMENT
Put forward approach of risk analysis through models	MODEL-BASED-RISK-ANALYSIS
Use of model management platform within the project	MODEL-MGT-PLATFORM
Create patterns per functional blocs of model	PATTERNS-FUNCTIONAL-BLOCS
Demonstrate the value of using modelling	VALUE-OF-MODELLING
Project characteristics relevant for the modelling effort	ME-PROJECT

Figure 13: Final coding list, page 5/6

	NOTE
Link between core concepts of ML and their elaboration!	CORE-CONCEPTS-TOWARDS-INNERSTRUCTURE
Puzzles to follow up on	NOTE-PUZZLE
Surprises	NOTE-SURPRISE
Purpose-related reflection by modeller	REFLECTION-PURPOSE-RELATED
Interaction at two levels- LF and conceptualisation	TWO-LEVELS-LINGUISTIC-FUNCTION
	SELECTED LANGUAGE CHARACTERISTICS
Abstraction level of selected modelling language	ML-ABSTRACTIONLEVEL
Framework of layers (design philosophy)	ML-LAYEREDFRAMEWORK
	SELECTED MODELLING TOOL CHARACTERISTICS

Figure 14: Final coding list, page 6/6

Instruments used in Data Condensing and Analysis

Modelling process overview. Figures 16–21 represent together the progress of modelling within the process, from the project timeline perspective. Each figure has two specific focuses, namely:

- Modelling-tasks level
- Modelling language-related level.

The symbols used in visualising modelling process are explained in Figure 15 below.

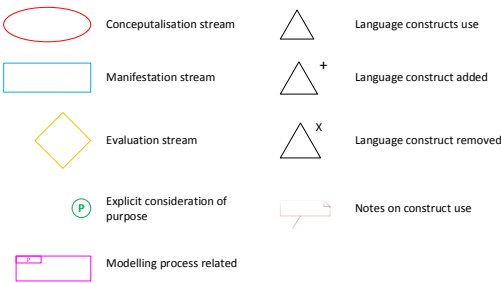


Figure 15: Symbols used in visualising modelling process in Figures 16- 21: legend

Modelling challenges and decisions. Figures 22–25 represent the first level of analysis of the challenges encountered and decisions taken in the modelling process. These are represented as they relate to model versions(namely Figure 22 and Figure 24), as well as in terms of classification according to the repetitive themes emerged in the process of modelling (namely Figure 23 and Figure 25).

Case dynamics. Figures 26–28 represent the synthesised view of the process and outcomes of the modelling effort, and the relationships between challenges and decisions taken, inferred from the available source material.

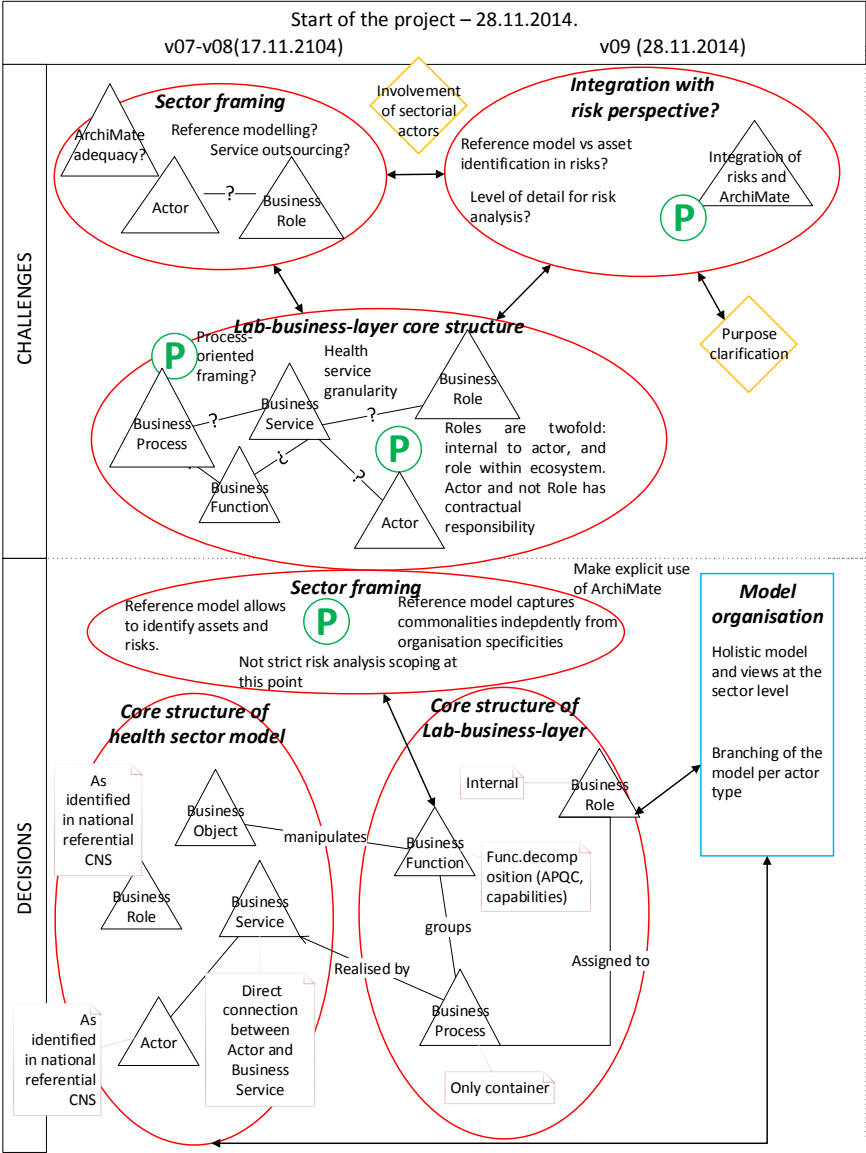


Figure 16: Overview of challenges and decisions in modelling effort - part 1/6

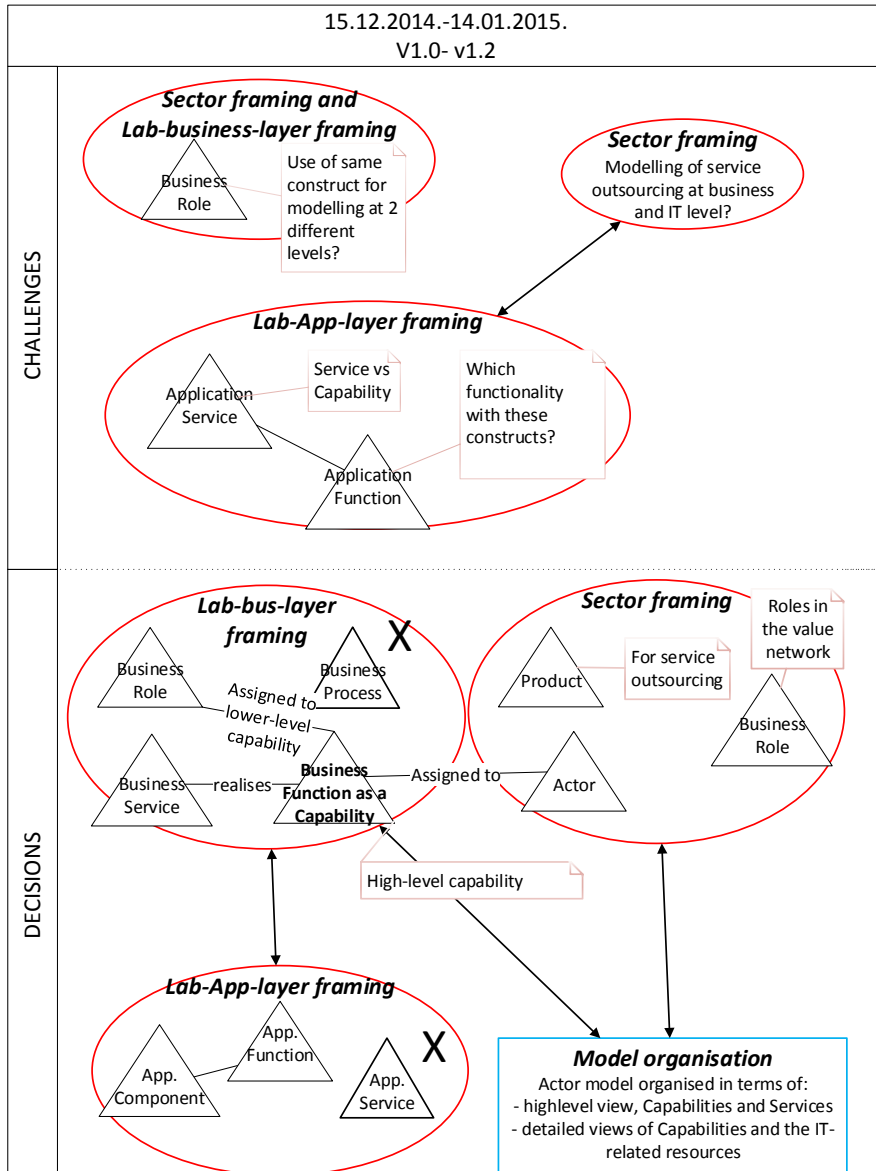


Figure 17: Overview of challenges and decisions in modelling effort - part 2/6

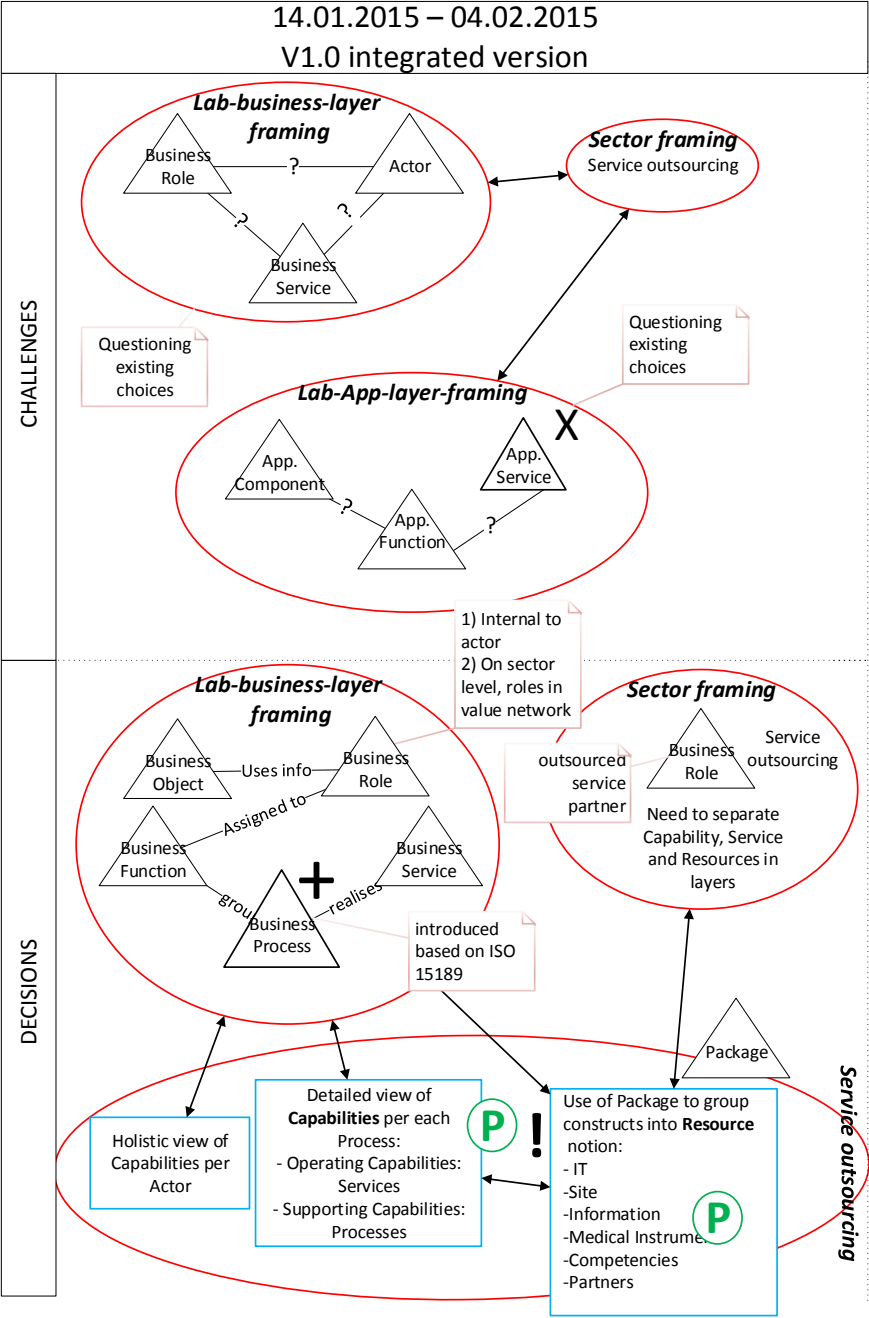


Figure 18: Overview of challenges and decisions in modelling effort - part 3/6

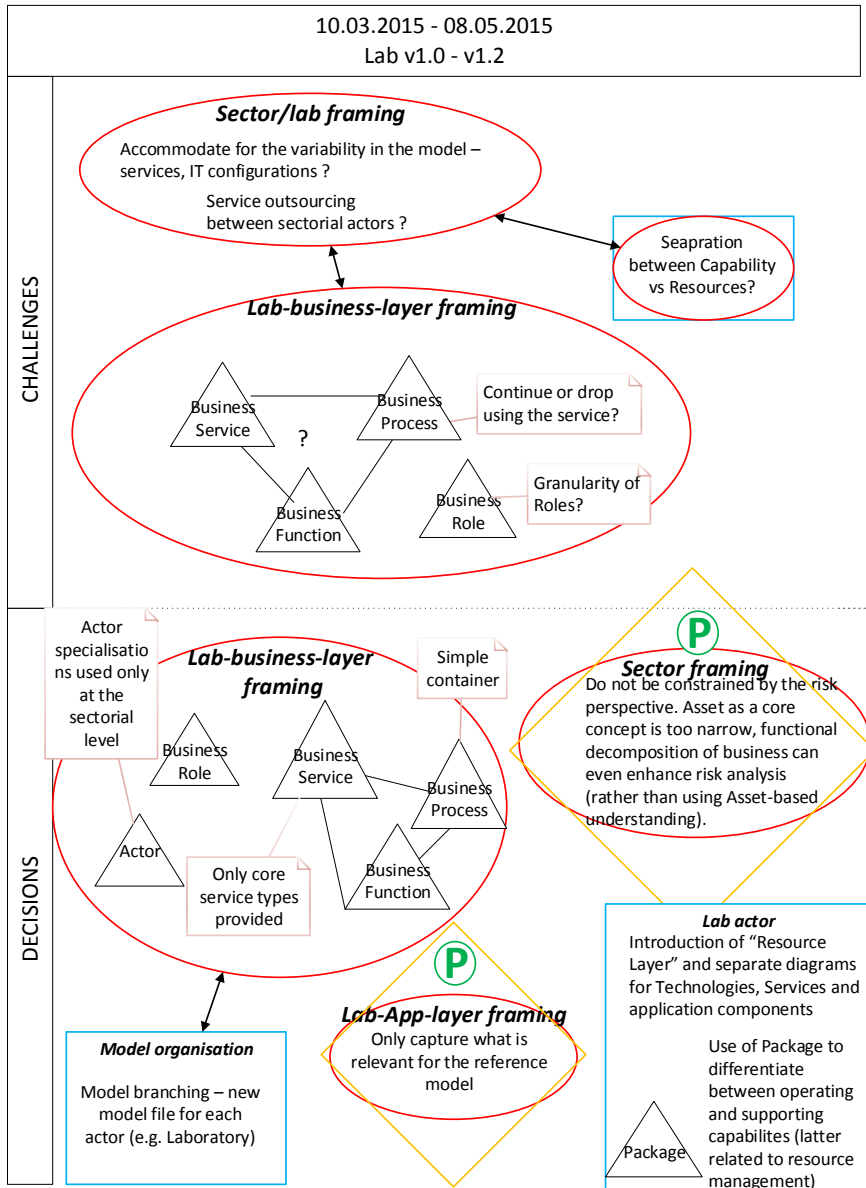


Figure 19: Overview of challenges and decisions in modelling effort - part 4/6

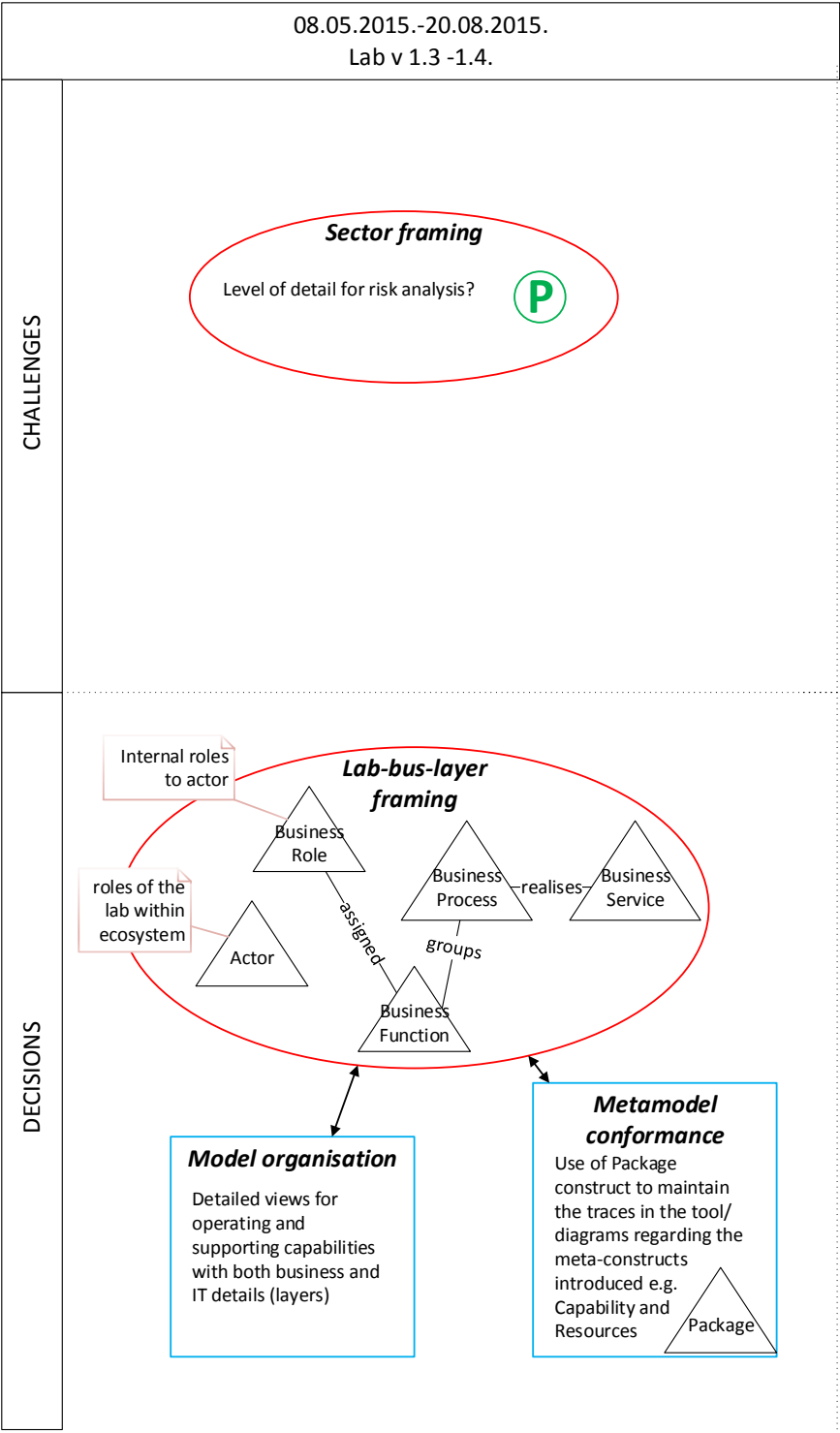


Figure 20: Overview of challenges and decisions in modelling effort - part 5/6

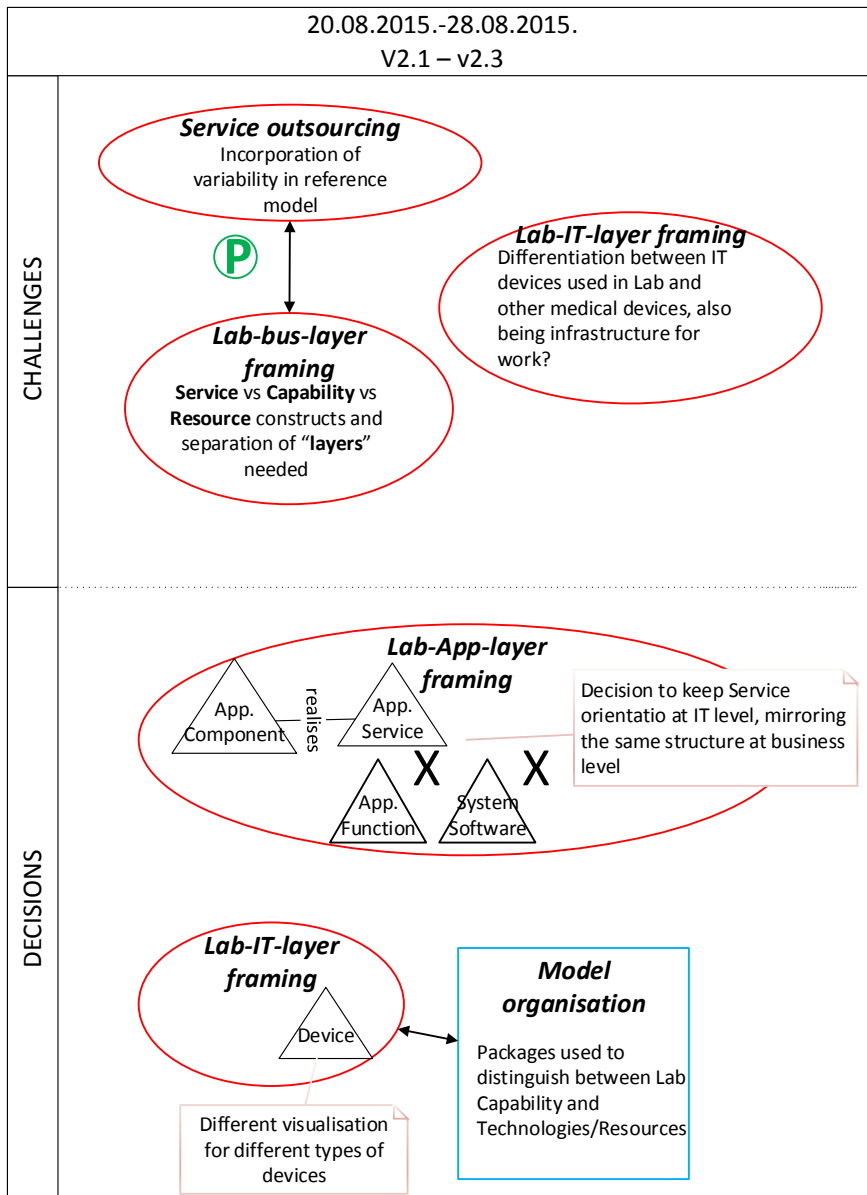


Figure 21: Overview of challenges and decisions in modelling effort - part 6/6

Challenge / Version	v0.8	v1.0	v1.2	v1.0 integrated	LAB v1.0	LAB v1.2	LAB v1.4	LAB v2.0	LAB v2.1	LAB v2.2
1 : ASSET-IDENTIFICATION	Yes	-	-	-	-	Yes	-	-	-	-
2 : IT-ROLE-ALIGNMENT	-	-	-	-	-	-	-	-	-	Yes
3 : LEVEL-OF-DETAIL-FOR-RISK-ANALYSIS	Yes	-	-	-	-	-	-	-	-	Yes
4 : RESOURCE-ALIGNMENT-RISK-HEALTH	-	-	-	-	-	-	Yes	-	-	Yes
5 : CAPABILITY-RESOURCE-SEPARATION-NEEDED	-	-	-	-	-	-	-	-	-	Yes
6 : HEALTH-SERVICE-GRANULARITY	Yes	-	-	-	-	Yes	-	-	Yes	Yes
7 : PROCESS-ORIENTED-FRAMING	Yes	Yes	-	-	-	Yes	-	-	-	-
8 : ROLE-OF-THE-ACTOR-DEFINITION	Yes	-	-	Yes	-	Yes	Yes	-	-	-
9 : ROLE-OR-ACTOR-WITH-SERVICE	-	-	-	Yes	-	-	-	-	-	-
10 : APPLICATIONS-MODELLING	-	-	Yes	Yes	-	-	-	-	-	Yes
11 : DEVICE-REPRESENTATION	-	-	-	-	-	-	-	-	-	Yes
12 : IT-RESOURCE	-	-	-	-	-	-	-	-	-	Yes
13 : SYSTEM-SOFTWARE-REPRESENTATION	-	-	-	-	-	-	-	-	-	Yes
14 : DISTINCTION-INSTANTIATION-CONFORMANCE	Yes	-	-	-	-	-	-	-	-	-
15 : INVOLVMENT-SECTORIAL-ACTORS	Yes	-	-	-	-	-	-	-	-	Yes
16 : RESOURCE-CONCEPT-LACKING	-	-	-	-	-	-	-	-	-	Yes
17 : VALUE-NETWORK-MODELLING-ARCHIMATE	Yes	-	-	-	-	-	-	-	-	-
18 : INCORPORATE-VARIABILITY-IN-REFMODEL	-	-	-	-	-	Yes	-	-	Yes	Yes
19 : SERVICE-OUTSOURCING-MODELLING	Yes	-	-	-	-	-	-	-	Yes	Yes

Figure 22: Challenges per model version – overview based on the coded content

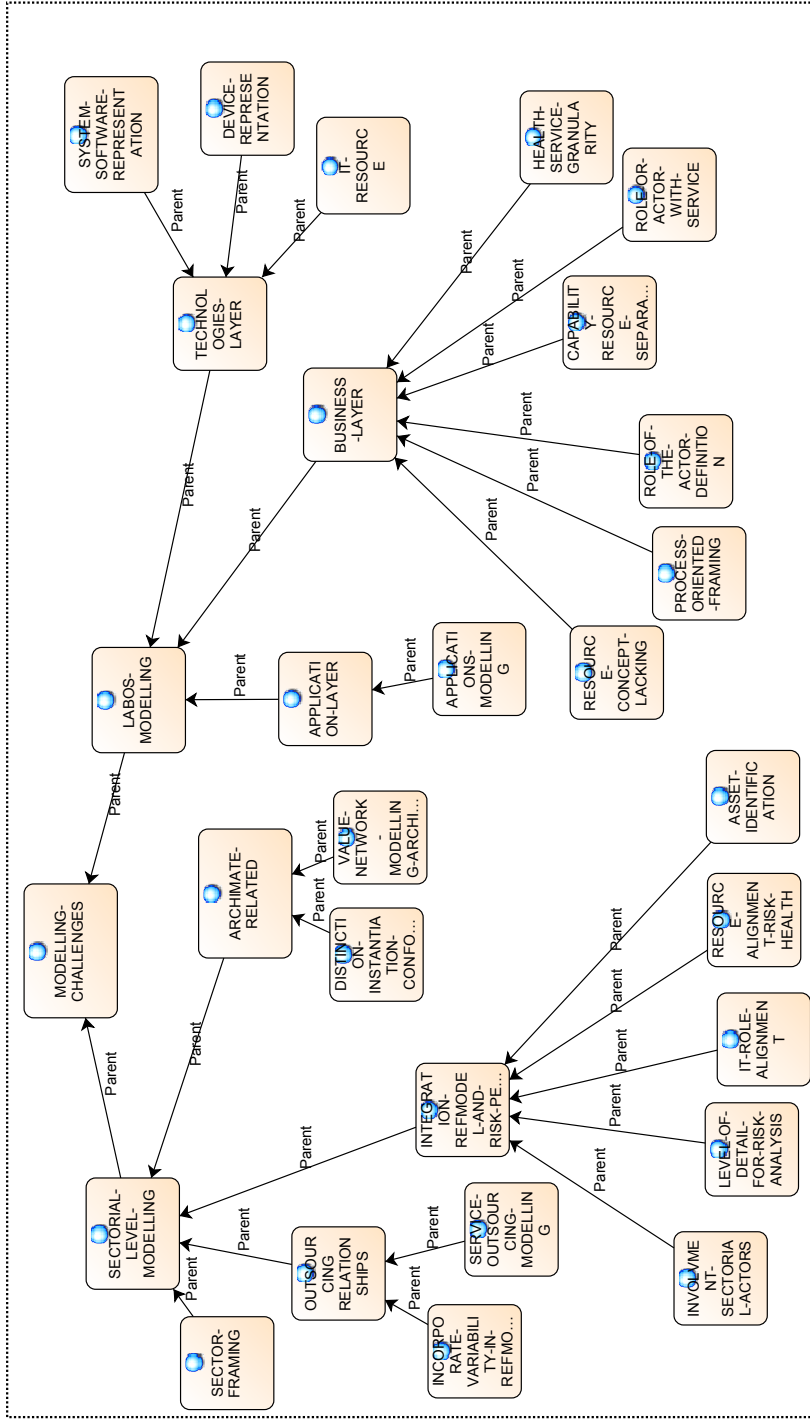


Figure 23: Modelling challenges – visualisation of the code classification

Decision / Version	v0.8	v1.0	v1.2	v1.0 integrated	LAB v1.0	LAB v1.2	LAB v1.4	LAB v2.0	LAB v2.1	LAB v2.2
1 : FUNCTIONAL-DECOMPOSITION	Yes	Yes	-	-	-	-	Yes	-	-	Yes
2 : LABOS-MODELLING	-	-	-	-	-	-	-	-	-	-
3 : CAPABILITY-RESOURCE-LAYERS	-	-	-	-	-	Yes	-	-	Yes	Yes
4 : SERVICE-CAPABILITY-LAYERS	-	-	-	Yes	-	-	-	-	Yes	Yes
5 : SERVICE-OUTSOURCING-PHILOSOPHY	-	Yes	-	Yes	-	-	-	-	Yes	Yes
6 : IT-BE-CONSTRAINED-BY-RISK-PERSPECTIVE	Yes	-	-	-	-	Yes	-	-	-	-
7 : PROCESS-REALISATION-OF-SERVICE	-	-	-	Yes	-	-	-	-	-	-
8 : REFERENCE-MODELLING-SECTOR	Yes	-	-	-	-	Yes	-	-	Yes	Yes
9 : RESOURCE-MODELLING	-	-	-	-	-	-	-	-	Yes	Yes
10 : RULES-FOR-CAPABILITY-IDENTIFICATION	-	-	-	Yes	-	-	Yes	-	-	-
11 : DEVICE-VISUALISATION	-	-	-	-	-	-	-	-	-	Yes
12 : IT-MODELLING-SCOPING-RELEVANCE	-	-	-	-	-	Yes	-	-	-	-
13 : KEEP-SERVICE-ORIENTATION-IN-IT-LAYER	-	-	-	-	-	-	-	-	-	Yes
14 : ACTOR-USE	Yes	-	-	Yes	Yes	-	Yes	-	-	-
15 : APPLICATION-COMPONENT-USE	-	-	-	-	-	-	-	-	-	Yes
16 : APPLICATION-FUNCTION-USE	-	-	Yes	-	-	-	-	-	-	Yes
17 : APPLICATION-SERVICE-USE	-	-	Yes	-	-	-	-	-	-	Yes
18 : BUSINESS-FUNCTION-USE	-	-	-	-	-	-	-	-	-	-
19 : BUSINESS-OBJECT-USE	Yes	-	-	Yes	-	-	Yes	-	Yes	Yes
20 : BUSINESS-PROCESS-USE	Yes	Yes	-	Yes	-	Yes	Yes	-	-	Yes
21 : BUSINESS-ROLE-USE	Yes	Yes	-	-	Yes	-	Yes	-	-	Yes
22 : BUSINESS-SERVICE-USE	-	-	-	Yes	-	-	-	-	Yes	Yes
23 : DEVICE-USE	-	-	-	-	-	-	-	-	-	Yes
24 : PACKAGE-USE	-	-	-	-	-	-	Yes	-	-	Yes
25 : SERVICE-ACTOR-RELATION	-	-	-	-	-	-	-	-	-	-
26 : ALIGNMENT-WITH-INDUSTRY-REFMODELS	Yes	-	-	-	-	-	Yes	-	Yes	Yes
27 : MAKE-EXPLICIT-USE-OF-ARCHIMATE	Yes	-	-	-	-	Yes	-	-	-	-
28 : MODEL-METAMODEL-ALIGNMENT	-	-	-	-	-	-	-	-	-	-
29 : COHERENCE-INTENTION-HOLISTIC-Vs-ACTORSIP	-	-	-	-	-	Yes	-	-	-	-
30 : BRANCHING-PER-ACTOR-TYPE	Yes	-	-	-	-	-	-	-	-	-

Figure 24: Decisions per model version – overview based on the coded content

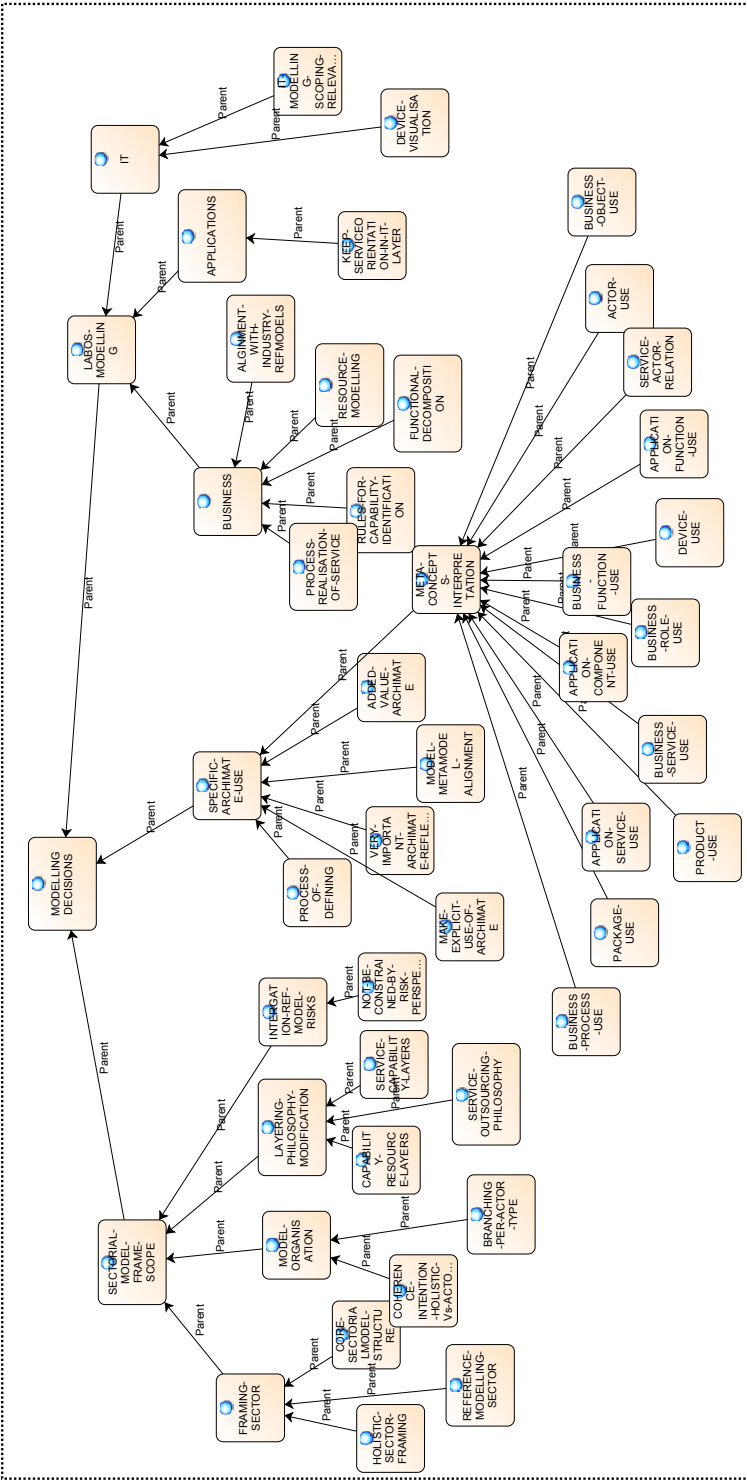


Figure 25: Decisions – visualisation of the code classification

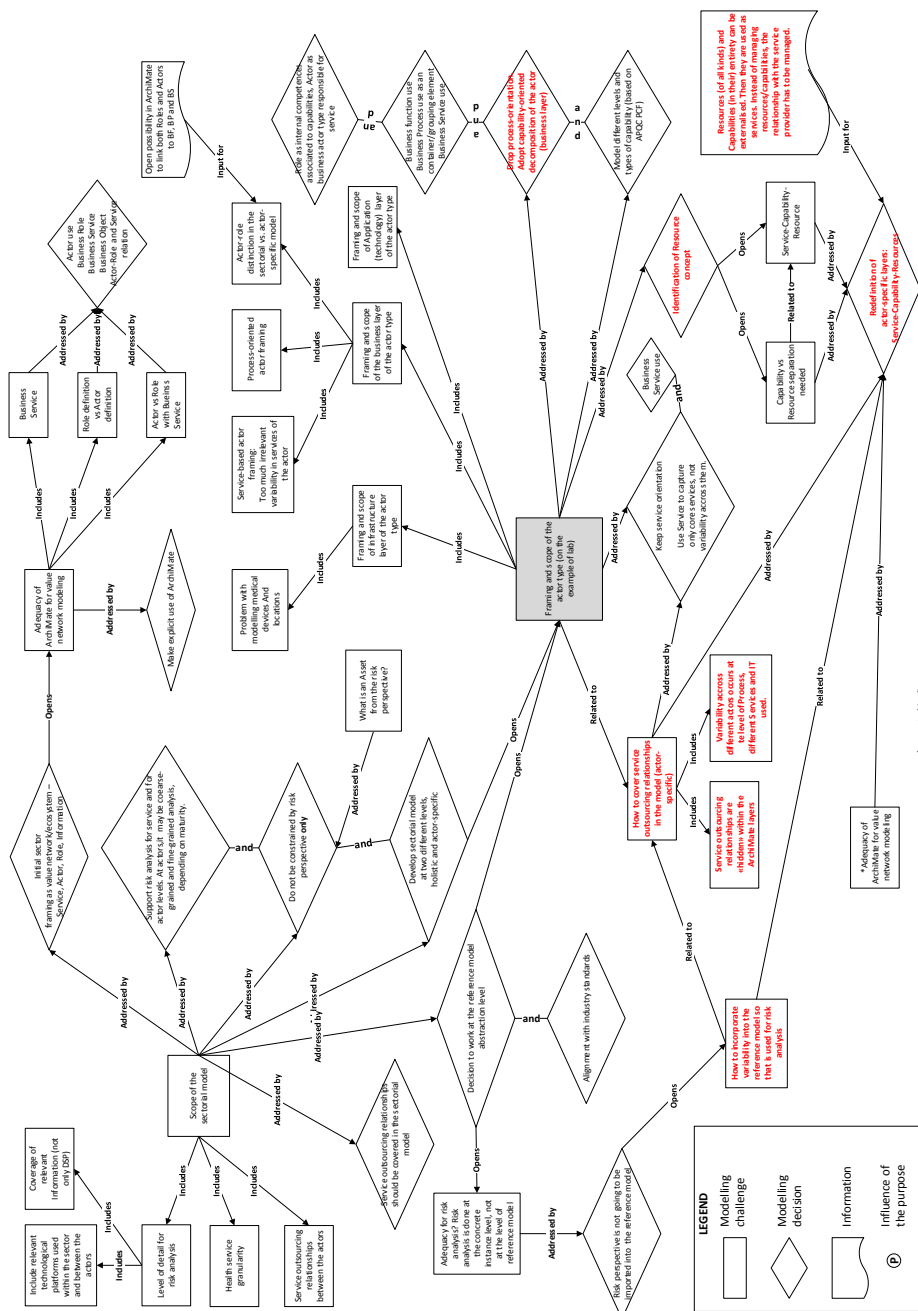


Figure 26: Case dynamics view: Modelling challenges, decisions and consequences on the model and language use, overview

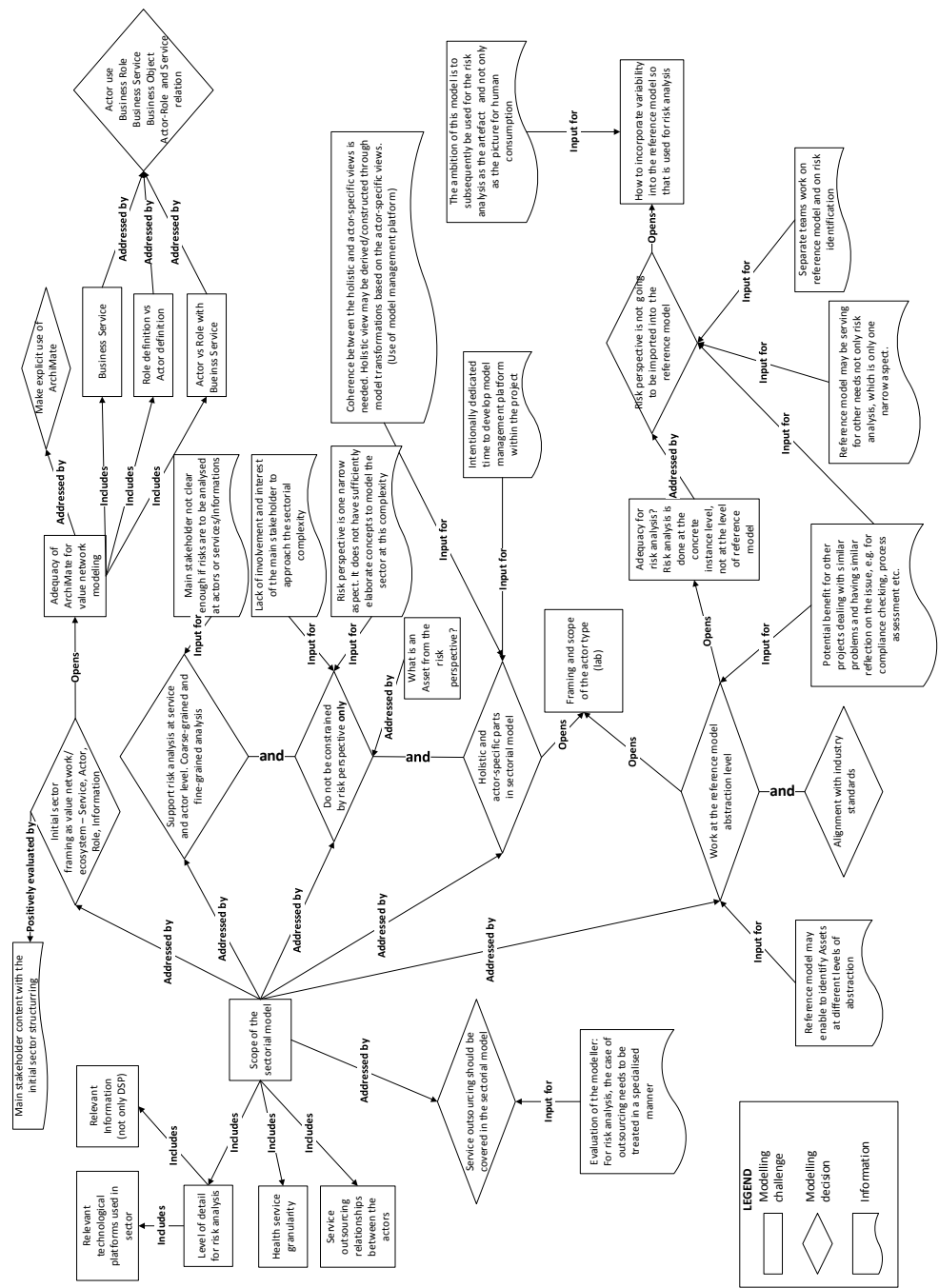
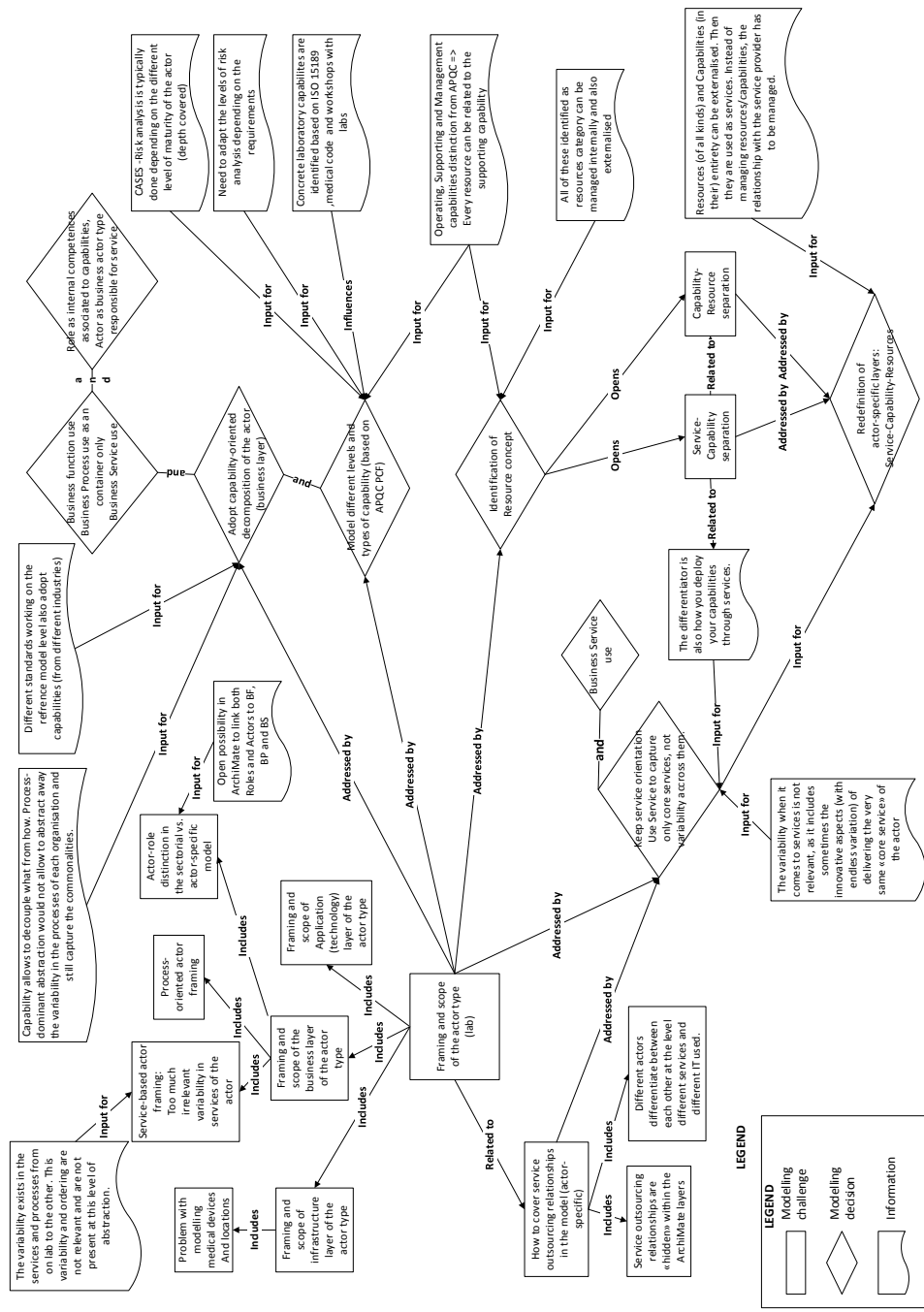


Figure 27: Case dynamics view: Modelling challenges, decisions and consequences on the model and language use, focussing on sector-level model



Summary

While language standardisation as a strategy is driven by legitimate ambitions of facilitating reuse and cost reduction, empirical evidence increasingly indicates that standardising effect of enterprise modelling languages erodes in their actual use. This is often due to the need to accommodate specific modelling contexts. From a pure engineering perspective, this is typically considered undesirable, and often has the connotation of undisciplined use, even abuse, of modelling languages. Instead of focussing on more strategies to control this phenomenon, we argue that it first requires a better fundamental understanding. In particular, we argue that the functioning of language in a wider socio-pragmatic context of modelling needs to be understood from a perspective that goes beyond the strictly normative view often adopted in design and evaluation of modelling languages.

This thesis focuses on developing a theoretical explanation of factors that affect modelling language use in the context of enterprise modelling, adopting the broader consideration of the roles that modelling language has in conceptual/enterprise modelling. The theoretical reflection in the thesis is developed from a socio-pragmatic constructivist stance. The choice of this paradigm of inquiry is influenced by the nature of our research subject, and an inherently pragmatic orientation on the phenomena of modelling, which is adopted in our research.

The explanatory theory is developed relying on our proposition of a theoretical framework for models, modelling and the role of conceptual modelling languages. Hence, the explanatory theory results from combining analytic and interpretive research approaches. On the analytic side, the thesis results in the following contributions. Firstly, we formulate a fundamental view on models and modelling, grounded in semiotics and cognitive sciences, which critically synthesises existing theoretical contributions. We add to the existing body of knowledge by proposing refinements regarding the crucial notions of domain and purpose, and by explicitly discussing the influence of purpose within the modelling process. Secondly, based on the aforementioned view, we study

conceptual modelling languages as having a twofold function in modelling, namely linguistic and representational function. In its linguistic function, a modelling language is intended to facilitate framing of discourse about a domain and shaping its conceptualisation. In its representational function, a modelling language aims to facilitate the expression of a purposeful model. In our research field, however, the linguistic function of a modelling language in relation to human conceptualisation is still not sufficiently understood. Current assumptions of language engineering and standardisation indeed neglect this function, and overemphasise the needs related to mechanical manipulations of models. Our thesis focuses on developing a thorough understanding of the linguistic function, as grounded in functional linguistics, cognitive linguistics, and cognitive science. In doing so, we work under the assumption that human use of conceptual modelling languages in conceptualisation is subject to principles that underlie formation, evolution and use of conceptual categories in natural languages. The insight in these reference disciplines enables us to devise a framework to characterise the inherent pragmatic rationale underlying the conceptual structure of a modelling language, and offers deeper understanding of the main factors that shape the capacity of a language to effectively mediate human conceptualisation processes. This lays the foundation for formulation of the explanatory theory.

On the interpretive side, the explanatory theory, initially theoretically driven, is confronted with, and refined through a field study in an enterprise modelling context. The interpretive field study has both a confirmatory and a revelatory role with respect to theoretical development. The resulting explanatory theory proposes that primary factors shaping enterprise modelling language use relate to its cost-effective functioning in terms of the linguistic and representational functions. Other factors such as available modelling infrastructure, ambition of knowledge capitalisation, resource availability, and politics, may attenuate these primary factors. With respect to the linguistic function, we observe that, contrary to the wide-spread assumption in our field, the linguistic framing of domain imposed by modelling language is not automatic, but that a continuous interaction takes place between (what one can refer to as) a pre-existent/default conceptualisation of a domain and the modelling language-biased framing of the domain. In this process, factors such as functional embodiment of the conceptual structure, its utility with regards to modelling context, but equally its pragmatic coherence, and method-like guidance of the use of language, have an effect on the success of the linguistic function. In particular, our research suggests that clear pragmatic rationale underlying conceptual structure may be one of the crucial qualities in the effective adoption and use of modelling languages, more than just clarity of definitions of the individual language constructs. Not only does the understanding of any conceptual system rest on this inherent rationale, but also each individual concept is understood in the relational web of this coherent whole. Our empirical insight indicates that the lack of such pragmatic coherence hinders the understanding, acquisition and use of the conceptual structure of the modelling language, and may require some form of method-like guidance to attenuate this negative effect. Finally, our findings also suggest that a clear pragmatic coherence of the linguistic structure

of modelling language may be crucial in communicating the competence area of a modelling language, and thus in avoiding its inappropriate application.

With respect to conceptual and enterprise modelling language research, the results of our thesis contribute at several levels. Firstly, the proposed theoretical contribution provides a basis for the study of conceptual and enterprise modelling languages, from a perspective which is alternative to, yet in a way complementary to, the ontological approach which dominates conceptual modelling research. This framework complements the isolated study of syntactic-semantic code with insights into the pragmatics of modelling and modelling languages, while drawing on insights into context- and intention-dependency, as well as the evolving nature, of both conceptual knowledge and language.

In addition, while pragmatics has often been considered as a source of problems in language analysis, the results of our research provide a different perspective on this problem, and suggests ways to make pragmatics an integral part of the study of conceptual and in particular enterprise modelling. By setting aside traditional syntax-semantic-pragmatic analytic distinction in linguistic study, we approach linguistic structure of a modelling language primarily as a conceptual system carrying some knowledge. The understanding of principles behind structuring and use of such conceptual systems also offers implications for the teaching of conceptual modelling. More than learning individual concepts and rules for their combination, our theory suggests that to effectively learn the language, more focus should be put on clarifying the conceptual perspective incorporated in the language, as well as the pragmatic scope and core of its conceptual structuring. These elements communicate the essence of the way of thinking behind any conceptual modelling language, while other intricacies can only be understood against this background. This insight offers an orientation towards conceiving language training programs.

Towards language engineering and standardisation, our findings suggest that more flexible and evolutionary approaches to modelling languages may be promising in enterprise modelling. For instance, instead of a normative perspective on modelling language, the relaxed notion of reference language may prove to be more appropriate. As long as the reference language is grounded in the practices and languages within the relevant domains, this notion is more in tune with the forms and mechanisms of knowledge capitalisation inherent in human cognitive functioning. This in turn suggests that language engineering research, as well as modelling support development, should place more focus on the mechanisms in support of modelling language flexibility and adaptability towards specific enterprise modelling contexts. Nonetheless, the decisions regarding modelling language scope, as well as factors and aspects subject to adaptation/variation, are not trivial. To this end, we believe that our theoretical framework and explanatory theory provide support to integrate pragmatics into language design.

Samenvatting

Standaardisatie van modelleertalen is een strategie die gedreven wordt door de goed te verantwoorden ambitie om hergebruik en kostenreductie te realiseren. Toch komt er steeds meer empirisch bewijs dat het standaardiserende en integrerende effect van enterprise modelling talen erodeert als ze echt gebruikt worden. Dit is te wijten aan de noodzakelijke aanpassing aan specifieke modelleercontexten. Vanuit een engineering perspectief wordt dit typisch gezien als een ongewenst effect, dat vaak wordt geassocieerd met ongedisciplineerd gebruik, zelfs misbruik, van modelleertalen. In plaats van focussen op meer strategieën voor het inperken van dit fenomeen, zijn we van mening dat eerst meer begrip ervan nodig is. Meer in het bijzonder vinden we dat het functioneren van een modelleertaal in de bredere socio-pragmatische context van het modelleren begrepen moet worden vanuit een perspectief dat verder gaat dan de strikt normatieve invalshoek die vaak wordt gekozen in ontwerp en evaluatie van modelleertalen.

Deze thesis richt zich op het ontwikkelen van een theoretische verklaring van factoren die invloed hebben op het gebruik van modelleertalen in enterprise modelling context, waarbij we in de volle breedte kijken naar de rollen die modelleertalen spelen in conceptueel modeleren en enterprise modelleren. De theoretische reflectie in deze thesis berust op een socio-pragmatische, constructivistische benadering. De keuze voor dit onderzoeksparadigma is beïnvloed door de aard van het onderwerp en een inherent pragmatische oriëntatie op het fenomeen ‘modelleren’.

De verklarende theorie wordt ontwikkeld op basis van ons voorstel voor een theoretisch raamwerk voor modellen, modelleren en de rol van conceptuele modelleertalen. De verklarende theorie komt tot stand door het combineren van analytische en interpretatieve onderzoeksmethoden. Aan de analytische kant zijn er de volgende resultaten. Allereerst formuleren we een fundamentele kijk op modellen en modelleren, geworteld in de semiotiek en cognitiewetenschap, die een synthese is van bestaande theoretische bijdragen. We breiden de bestaande kennis op dit gebied uit door een verfijning voor te stellen betref-

fende de cruciale begrippen ‘domein’ en ‘gebruiksdoel’, en door het expliciet bespreken van de invloed van ‘gebruiksdoel’ binnen het modelleerproces. Op de tweede plaats bestuderen we conceptuele modelleertalen, vanuit het hiervóór genoemde uitgangspunt, ervan uitgaande dat deze twee functies hebben bij het modelleren, namelijk de talige en de representerende functie. In zijn talige functie is een modelleertaal bedoeld voor het helpen inkaderen van de conversatie over een domein, en het vormen van de conceptualisatie daarvan. In zijn representerende functie is een modelleertaal bedoeld om het uitdrukken van een doelgericht model mogelijk te maken. In ons onderzoeksveld wordt de talige functie van een modelleertaal, in combinatie met menselijke conceptualisatie, nog onvoldoende begrepen. De gangbare aannames bij taalconstructie en standaardisatie negeren de talige functie en benadrukken factoren ingegeven door het belang van mechanistische manipulaties van modellen. Onze thesis richt zich opeen diepgaand begrip van de talige functie, op basis van functionele linguïstiek, cognitieve linguïstiek, en cognitiewetenschap. Daarbij gaan we ervan uit dat menselijk gebruik van conceptuele modelleertalen in conceptualisatie onderhevig is aan dezelfde principes die gelden bij de vorming, evolutie en het gebruik van conceptuele categorieën in natuurlijke taal. Inzichten vanuit deze disciplines stellen ons in staat een raamwerk op te stellen dat de inherent pragmatische rationale zichtbaar maakt die ten grondslag ligt aan de conceptuele structuur van een modelleertaal. Het maakt een fundamenteel begrip mogelijk van de belangrijkste factoren achter de capaciteit van een taal om menselijke conceptualisatie effectief te mediëren. Dit legt het fundament voor het formuleren van onze verklarende theorie.

Aan de interpretatieve kant testen en verfijnen we de verklarende theorie met behulp van een veldstudie in een enterprise modelling context. Deze interpretatieve veldstudie wordt gedaan ter bevestiging en verdere uitwerking van de theorie. De resulterende theorie stelt dat de primaire factoren die het gebruik van een enterprise modelling taal beïnvloeden, samenhangen met het rendabel functioneren daarvan binnen de talige en representerende functies. Andere factoren kunnen een verzachtende werking hebben, zoals beschikbare modelleer-infrastructuur, ambitie voor het veilig stellen van kennis, politiek, en de beschikbare resources. Wat betreft de talige functie observeren we, in tegenstelling tot een veelvoorkomende aanname in het veld, dat de talige inkadering van een domein door een modelleertaal niet vanzelfsprekend is, maar dat er een continue interactie is tussen (wat men kan zien als) een bestaande/default conceptualisatie van een domein en de door de modelleertaal ingegeven conceptuele inkadering van het domein. In dit proces hebben diverse factoren een effect op het welslagen van de talige functie: functionele belichaming van de conceptuele structuur, de gebruikswaarde vanuit de modelleercontext, maar ook de pragmatische samenhang, en de methodische aansturing van het gebruik van de modelleertaal. Ons onderzoek geeft vooral aan dat een heldere pragmatische rationale voor de conceptuele structuur een cruciale factor is in het effectief kiezen en gebruiken van modelleertalen, meer nog dan het helder definiëren van afzonderlijke taalconstructen. Het begrip van elk conceptueel systeem bouwt op deze rationale, maar tevens wordt elk individueel concept begrepen vanuit het relationele web van het samenhangende geheel. Ons em-

pirisch inzicht geeft aan dat het ontbreken van een dergelijke pragmatische samenhang het begrip, de verwerving en het gebruik van conceptuele structuren van de modelleertaal hindert, en dat een vorm van methodische begeleiding of aansturing dit negatieve effect kan helpen verzachten. Tot slot suggereren onze bevindingen dat een duidelijke pragmatische coherentie van de taalstructuur van een modelleertaal bepalend kan zijn voor goede communicatie over het toepassingsbereik van een modelleertaal, en dus kan helpen toepassing in ongeschikte gevallen te vermijden.

Wat betreft het onderzoek naar conceptual modelling en enterprise modelling talen dragen onze bevindingen bij op diverse niveaus. Allereerst legt ons theoretisch raamwerk een basis voor studie van conceptual modelling en enterprise modelling talen vanuit een alternatief perspectief dat tevens complementair is aan de ontologische invalshoek die dominant is in onderzoek naar modelleren. Het raamwerk vult de afzonderlijke studie van syntactisch-semantische code aan met inzichten in de pragmatiek van modelleren en modelleertalen, waarbij ook gebruik gemaakt wordt van inzichten in context-afhankelijkheid en intentie-afhankelijkheid, en tevens in de evoluerende aard van zowel conceptuele kennis als taal.

Waar pragmatiek vaak gezien wordt als een bron van problemen in taalanalyse, biedt ons onderzoek een ander perspectief op deze problematiek, en biedt het mogelijkheden om pragmatiek een integraal deel te maken van de studie van conceptual modelling, en in het bijzonder enterprise modelling. Door het opzij zetten van het traditionele syntax-semantiek-pragmatiek onderscheid in linguïstisch onderzoek benaderen we de taalstructuur van een modelleertaal primair als een conceptueel systeem dat kennis draagt. Het begrip van principes voor het structureren en gebruiken van conceptuele systemen heeft ook implicaties voor het onderwijzen van conceptual modelling. Meer dan het aanleren van individuele modelleerconcepten en regels voor het combineren daarvan, suggereert ons onderzoek dat voor het effectief leren van een modelleertaal meer nadruk moet worden gelegd op het verhelderen van het conceptuele perspectief dat in de taal ingebouwd zit, evenals de pragmatische reikwijdte en kern van de conceptuele structuur ervan. Deze onderdelen communiceren de essentie van de 'way of thinking' achter een modelleertaal, en maken begrip mogelijk van andere genuanceerde aspecten. Dit kan invloed hebben op het samenstellen van trainingsprogramma's.

Voor taalconstructie en standaardisatie houden onze inzichten in dat meer flexibele en evolutionaire benaderingen van modelleertalen veelbelovend zijn voor enterprise modelling. Bijvoorbeeld kan een versoepelde kijk op referentietalen, als alternatief voor een normatieve benadering, geschikter blijken. Zolang de referentietaal geworteld is in de gebruikspraktijk en –taal in de relevante domeinen is deze benadering meer in lijn met de vormen en mechanismes van kennisbehoud en kennis-kapitalisatie inherent in het menselijk cognitief functioneren. Dit suggereert dan weer dat onderzoek naar taalconstructie, evenals ontwikkeling van ondersteuning voor modelleren, meer aandacht zou moeten schenken aan mechanismes die flexibele modelleertalen ondersteunen, als ook de aanpasbaarheid aan verschillende enterprise modelling contexten. Niettemin blijft het lastig beslissingen te nemen met betrekking tot de scope van

een modelleertaal, en tot factoren en aspecten gerelateerd aan aanpassing en variatie. Daarom denken wij dat ons theoretisch raamwerk en onze verklarende theorie steun bieden bij het integreren van pragmatiek in overwegingen bij taalontwerp.

Curriculum Vitae

Marija Bjeković(*married* Bjeković–Obradović) is a PhD candidate in Information Science at Radboud University Nijmegen, the Netherlands. Her doctoral research is conducted under the guidance of Prof. Henderik Proper at the Luxembourg Institute of Science and Technology (LIST), and is co-funded by LIST and *Fonds National de la Recherche Luxembourg*, via the PEARL programme. Marija’s research is concerned with the fundamental understanding and explanation of enterprise modelling language use. Marija’s educational background combines information systems and organization sciences. She obtained her diploma of Engineer in Organisation Sciences, specialising in Information Systems, from University of Belgrade, Serbia in 2003. This program had a rare and highly appreciated breadth and multi-disciplinarity compared to a typical IS curriculum. Marija holds the Master degree of Economic and Management Sciences from University of Savoie, France, obtained in 2005. Marija worked as information systems engineer in Serbia, and research engineer in LIST, prior to embarking on a PhD project. She is currently working at LIST as research associate in the team concerned with modelling of service-intensive systems, led by Prof. Henderik Proper.

The Enterprise Engineering Network

Background

The Enterprise Engineering Network (EE Network, www.ee-network.eu) is a research and training network targeting PhD candidates and research fellows. Next to the supervision of PhD candidates and research fellows, the main activities of the network involve:

- Research seminars;
- Events targeting interaction with practitioners;
- Events targeting interaction with M.Sc. students;
- Development of a joint curriculum for EE Network researchers and associated courses;
- Co-organisation of scientific events.

The hosts of the network are also concerned with formulating and conducting joint research projects. Yet, the EE Network itself focuses on the actual training activities.

The history of the EE Network, and its direct predecessors, can be traced back to 2001. It is currently hosted at five locations:

1. **Headquarters:** IT for Innovation Services department of the Luxembourg Institute of Science and Technology, Belval, Luxembourg;
2. Model Based System Development department of the Institute for Computing and Information Sciences of Radboud University, Nijmegen, the Netherlands;
3. HAN University of Applied Science, Arnhem, the Netherlands;

4. Information Systems Architecture group of Utrecht University of Applied Science, Utrecht, the Netherlands;
5. Individual and Collective Reasoning and Model Driven Engineering groups of University of Luxembourg, Belval, Luxembourg.

To enable a practical operation of the training activities, in particular in for the research seminars, the EE Network has a traditional geographical focus on the Rhine-Scheldt-Meuse-Moselle basin, which includes the Low Countries (Belgium, Netherlands and Luxembourg), the Rhineland in Germany, as well as Lorraine in France.

Finished dissertations

Dissertations produced in the EE Network, and its direct predecessors, include:

- 2018-1** M. Bjeković, *Pragmatics of Enterprise Modelling Languages: A Framework for Understanding and Explaining*, Radboud University Nijmegen, Nijmegen, the Netherlands, January 12, 2018
- 2017-1** G. Plataniotis, *EA Anamnesis – A Conceptual Framework for Enterprise Architecture Rationalization*, Radboud University Nijmegen, Nijmegen, the Netherlands, April 4, 2017
- 2016-2** R. Ettema, *Using triangulation in Lean Six Sigma to explain quality problems - An enterprise engineering perspective*, Radboud University Nijmegen, Nijmegen, the Netherlands, December 14, 2016
- 2016-1** H. Faller, *Organizational Subcultures and Enterprise Architecture Effectiveness: an Explanatory Theory*, Radboud University Nijmegen, Nijmegen, the Netherlands, March 4, 2016
- 2015-2** L.J. Pruijt, *Instruments to Evaluate and Improve IT Architecture Work*, University of Utrecht, Utrecht, the Netherlands, November 25, 2015.
- 2015-1** D.J.T. van der Linden, *Personal semantics of meta/concepts in conceptual modeling languages*, Radboud University Nijmegen, Nijmegen, the Netherlands, February 13, 2015.
- 2014-2** C. Feltus, *Aligning Access Rights to Governance Needs with the Responsibility MetaModel (ReMMo) in the Frame of Enterprise Architecture*, University of Namur, Namur, Belgium, March 11, 2014.
- 2014-1** F. Tulinayo, *Combining System Dynamics with a Domain Modeling Method*, Radboud University Nijmegen, Nijmegen, the Netherlands, January 27, 2014.
- 2013-2** C. Brandt, *An Enterprise Modeling Framework for Banks using Algebraic Graph Transformation*, Technische Universität Berlin, Berlin Germany, December 20, 2013.
-

- 2013-1** R. Wagter, *Enterprise Coherence*, Radboud University Nijmegen, Nijmegen, the Netherlands, November 19, 2013.
- 2012-2** A. Nakakawa, *A Collaborative Process for Enterprise Architecture Creation*, Radboud University Nijmegen, Nijmegen, the Netherlands, November 21, 2012.
- 2012-1** D. Ssebuggwawo, *Analysis and Evaluation of Modelling Processes*, Radboud University Nijmegen, Nijmegen, the Netherlands, November 21, 2012.
- 2009-2** S. Overbeek, *Bridging Supply and Demand for Knowledge Intensive Tasks*, Radboud University Nijmegen, Nijmegen, the Netherlands, April 24, 2009.
- 2009-1** J. Nabukenya, *Improving the Quality of Organizational Policy Making using Collaboration Engineering*, Radboud University Nijmegen, Nijmegen, the Netherlands, March 3, 2009.
- 2006-1** B. van Gils, *Aptness on the Web*, Radboud University Nijmegen, Nijmegen, the Netherlands, March 3, 2006.
- 2004-1** S.J.B.A. Hoppenbrouwers, *Freezing Language – Conceptualisation Processes across ICT Supported Organizations*, Radboud University Nijmegen, Nijmegen, the Netherlands, December 10, 2004.
-

The standardization of enterprise modelling languages is often used as a platform to ensure the unification and integration of modelling perspectives and constructs for a problem area. Although rooted in legitimate ambitions, there is an increasing evidence of limits of such strategy in enterprise modelling, due to the need to accommodate specific modelling contexts. While this problem is traditionally scantily addressed in the research, in the context of enterprise modelling, adequate linguistic support has a central role in ensuring effective design and use of enterprise models.

This thesis focuses on understanding the role of conceptual/enterprise modelling languages and explaining their use. The theoretical reflection in this thesis offers a broader consideration of modelling languages, going beyond just the isolated study of syntactic-semantic code, and drawing on insights into context- and intention-dependency, and evolving nature of both conceptual knowledge and language. In particular, the nature of language support in relation to conceptualisation is more deeply studied. The main findings of this research suggest that clear pragmatic rationale underlying the linguistic structure of enterprise modelling language - more than clarity of individual construct definitions - is one of the crucial qualities for ensuring its effective understanding, learning and use. These results offer an interesting set of insights for conceptual modelling research, in particular towards language engineering and teaching of conceptual/enterprise modelling.